SCIENCE

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FRIDAY, MARCH 9, 1900.

CONTENTS:

Professor Thomas Egleston: PROFESSOR A. J. MOSES..... 361

The Seventieth Birthday of Carl von Kupffer.—His Life and Works: PROFESSOR BASHFORD DEAN.. 364

Recent Progress in Geodesy: DR. J. F. HAYFORD..... 369

The Plankton of Fresh Water Lakes: C. DWIGHT MARSH.. 374

Scientific Books:—
The Cambridge Natural History: PROFESSOR J. H. COMSTOCK. *Traité de Zoologie Concrète:* DR. GARY N. CALKINS. *Palæzoic Reticulate Sponges:* CHARLES SCHUCHERT. *Books Received*..... 389

Scientific Journals and Articles..... 392

Societies and Academies:—
The Annual Meeting of the New York Academy of Sciences: PROFESSOR RICHARD E. DODGE. *American Mathematical Society:* PROFESSOR F. N. COLE. *The Texas Academy of Science:* F. W. S..... 393

Discussion and Correspondence:—
Marginal Tabs for Logarithm Tables: PROFESSOR H. W. HOLMAN..... 396

Notes on Physics: F. C. C..... 396

Zoological Notes:—
Bird Migration, The Stereornithes Again: F. A. L..... 397

The Assay Commission..... 397

Scientific Notes and News 398

University and Educational News..... 400

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PROFESSOR THOMAS EGLESTON.

THOMAS EGLESTON, planner and first professor of the School of Mines of Columbia University, died on Monday morning, January 15th, at his home, 35 West Washington Square, New York City, at the age of sixty-seven years.

Professor Egleston was born in New York City, December 9, 1832. He prepared for college under Dr. Dudley, of Northampton, took the regular four years' classical course at Yale and graduated in 1854; and in the following year took a post graduate course in the Yale Scientific School of Analytical Chemistry under Professor Benjamin Silliman, Jr.

In 1856 he went to Europe more for rest than to pursue any special course of study, but, becoming interested in the lectures in geology and chemistry at the Jardin des Plantes of Paris, he spent a good deal of time in the collections and laboratories and later, desiring to pursue more systematic work, applied for and obtained the permission of the government to attend certain lectures at the École des Mines, especially those of Professor de Senarmont on Mineralogy, of Elie de Beaumont on Geology, and of Professor Bayle on Paleontology. He completed his course at the school in 1860, having not only attended the lectures but worked in all the laboratories. During the vacations and at the close of his course he travelled extensively in France and Germany, studying and collecting.

In 1861 Mr. Egleston returned to New York city and was at once chosen by the Smithsonian Institution at Washington to take charge of the work of sorting and arranging the specimens of minerals and rocks which had accumulated as a result of various exploring expeditions. To facilitate the work and assist in the system of international exchanges then undertaken, he prepared a check list of minerals with their compositions, which was published by the Institution.

At this time the need for a school of mines and metallurgy in this country was beginning to be recognized. Schools of civil engineering existed and schools of science, but nothing especially devoted to mining or metallurgy. Mining operations were conducted by so called 'practical miners,' with here and there a graduate of a foreign school, and the waste and mismanagement were almost beyond belief.

The nearest previous approach to the formation of such a school is found in the incorporation in New York State, about 1859, of the 'American School of Mines' with the avowed object of "The economic and scientific development of the mineral wealth of the United States, the determination of its economic values, instruction in the art of practical mining and the analysis and composition of mineral products." This institution does not appear ever to have reached a stage of active existence.

Dr. Egleston prepared and published in March, 1863, a 'Proposed Plan for a School of Mines and Metallurgy in New York City,' which was simple and practical and founded undoubtedly upon the methods pursued at the École des Mines. In about 1500 words he stated the object of the school, the proposed course of instruction, and the estimated cost of establishment.

The object stated was "To furnish to the student the means of acquiring a thorough scientific and practical knowledge of those branches of science which relate to mining and the working up of the mineral resources of this country, and to supply to those engaged in mining and metallurgical operations, persons competent to take charge of new or old works and to conduct them on thoroughly scientific principles." A course of three years was outlined which was closely adhered to for the first few years of the school and then gradually modified. The estimated cost of equipment was $17,300, of which over half was for collections.

Dr. Egleston's idea appears to have been to graft the school upon some existing institution, and fortunately he submitted the plan to the Trustees of Columbia College, who for four or five years had been considering the extension of the work of the college by the establishment of graduate schools, among others a 'practical school of science.' The opportunity to make a first step in this direction seemed to exist in the plan of Dr. Egleston, for it was proposed to pay all expenses of the school from the fees, and while the organization as planned required a larger outlay than the financial condition of the college warranted, the committee of the Trustees reported that, "the nucleus of such a school could be formed at inconsiderable cost to the college and so as to be capable of expansion whenever the means of the college shall permit." The Trustees, thereupon set apart rooms in the college building for mineralogical and geological collections, appropriated $500, for fitting up cases and, on February 1, 1864, appointed Thomas Egleston, Jr., Professor of Mineralogy and Metallurgy without salary.

Although no money was appropriated with which to buy collections of minerals or rocks, the small collection of the college was placed at the disposal of the new school, and Dr. Egleston obtained gifts from Mr. George T. Strong and the Hon. Gouverneur Kemble, with which two private col-

lections of considerable value were purchased. From these, before the opening of the school, he formed a very fair working collection of minerals and a smaller geological collection.

An assay room, with a furnace for every four students, and a chemical laboratory were fitted up in one of the cellars. As one of the first students writes: "Though the actual state of these necessary aids to study was not good, the collections were all planned on a great scale and as far as possible the work was done thoroughly. The assay laboratory was the best in the country, the crystal models for every day use more abundant and complete than in any other school in the world. The best design was sought in tables and cabinets, and with all its shortcomings the new institution not only gave full promise of its present state of perfection, but was in fact superior in some respects to any existing at the time."

On November 15, 1864, the school opened with fifteen students, which by the end of the month had risen to twenty-nine and a little later to forty-three, the list including graduates of common schools and colleges, business men and civil engineers in full practice.

Early in 1865 the trustees recognized the success of the experiment and definitely made the School of Mines a coördinate branch of Columbia College. It has steadily developed, widening by the addition of courses in civil engineering, chemistry, architecture, electrical engineering, sanitary engineering and mechanical engineering into the existing cluster of schools in applied science under one faculty, with 1300 graduates and over 2000 others who have attended partial or special courses.

In the first four years of the School of Mines Dr. Egleston devoted himself to the preparation of lectures in mineralogy and metallurgy, to the accumulating and bringing into shape the mineralogical collection and to the preparation of needed text-books. All his publications prior to 1872, with the exception of a report upon a 'geological and Agricultural Survey of the first hundred miles of the Union Pacific Railroad,' which he conducted in 1866, were text-books, tables and catalogues for the use of students of the School of Mines. It is noteworthy that while Dr. Egleston's first love was mineralogy and, as he expressed it, he "only took charge of metallurgy because at the time he could not persuade anyone else to take it," yet after the completion of his text-books in mineralogy he did little or no work in this direction, except in the development of the collection. In the collection work he never relaxed and even the year of his retirement, when grievously broken in health, insisted on personally choosing and setting in the new specimens.

In metallurgy, on the contrary, he published nearly one hundred books and papers, covering a wide field and to a very great extent the result of data collected in his yearly trips to different parts of the world. This complete passing into metallurgy was practically coincident with and in a measure caused by the founding of the American Institute of Mining Engineers in 1871. Dr. Egleston was approved for membership at the first meeting and thereafter for over twenty years was one of its most vigorous members, twice a manager, three times vice-president, and in 1887 president. He contributed to their transactions over thirty articles, and in this same period he published over twenty articles, principally metallurgical, in the *School of Mines Quarterly*, and contributed also papers to the American Society of Civil Engineers and American Society of Mechanical Engineers, The New York Academy of Sciences, and in the *London Engineering* he published a long series of articles upon the Metallurgy of Silver, Gold and Mercury in the United States, which, with other matter, were re-

printed in two large volumes in 1887 and 1890, and constitute his most ambitious work.

Aside from his scientific work, Dr. Egleston took a very active part in religious and charitable work. He was a vestryman of Trinity Church for twenty years, and at the time of his death was Junior Warden, as well as member of several committees. For nearly thirty years he was Vice-President of the Protestant Episcopal Mission Society and a Trustee of the General Theological Seminary. He is also to be credited with the establishment of 'Food Kitchens' in New York, and with organizing the Public Parks Association by which Washington Square was saved. The Audubon Monument movement was also started by him.

In 1874 Princeton conferred upon him the degree of Ph.D., and Trinity that of LL.D. In 1890 he was appointed a Chevalier of the Legion of Honor by the French government on the recommendation of the Director and members of the Faculty of the École des Mines. In 1895 he was made 'Officier.' It is pleasant to record also that since his death the Trustees of Columbia University have named the Museum of Mineralogy the 'Egleston Mineralogical Museum,' thus attaching his name permanently to the collection which he created and loved.

In 1896 his health gave way, and though after a rest he endeavored to resume his work, he could not stand the strain and was retired June 30, 1897, at his own request, as Professor Emeritus.

The service of Dr. Egleston to science lies not so much in his numerous writings, though these contain an enormous mass of valuable information collected with infinite labor and published always when and where they were needed. Far more important was what has been happily called 'his intuitive perception of the situation,' his recognition of when the time was ripe to inaugurate a movement, his skill in organization and the amazing vigor, persistency and unfailing belief with which he forced it to success. ALFRED J. MOSES.

THE SEVENTIETH BIRTHDAY OF CARL VON KUPFFER.—HIS LIFE AND WORKS.

PROFESSOR VON KUPFFER has lately passed the mark of three score years and ten and has received the congratulations of his students of many lands. Some of these, following the good German custom, have prepared memoirs in his honor which appear in a memorial volume and were presented him as a birthday gift. Von Kupffer has been a most helpful friend to the Americans who have carried on their investigations in the Anatomical Institute in Munich during the past generation, and it seems but just that at this time an American journal should pay a tribute to his life and work.—EDITOR OF SCIENCE.

Carl von Kupffer ranks to-day as one who has taken a place within the innermost circle of comparative embryologists. He has long been recognized as a profound scholar in a broad field of zoological knowledge; he is best known, however, for his researches upon the structure, development and descent of the vertebrates.

In his biography von Kupffer presents an interesting parallel with the great embryologist, Karl Ernst von Baer. Both were natives of the Baltic provinces of Russia, students and graduates of the University of Dorpat, and sometime practicing physicians until drawn into zootomical-embryological research. Both were for a time professors at Königsberg, and showed a distinct bent towards the widely separate themes of Arctic exploration and craniology; they were equally interested in matters relating to fish and fishery and contributed important memoirs to this subject. On the other hand they had in general but little leaning towards work of the systematst.

Both left Königsberg for wider fields, von Baer, however, to largely lay aside his embryological researches, the other to extend and correlate his. An interesting difference between the two embryologists is this, that von Baer had completed his most important work when he was scarcely over forty years of age, while von Kupffer had not begun his best known work until he was over sixty. A further difference is that Kupffer has held fast to the early themes of his research. Von Baer lived until his eighty-sixth year; von Kupffer has entered his eighth decade with every prospect of many years of active work.

Von Kupffer has devoted forty-five years to his researches. And these he has embodied in upwards of fifty memoirs. The number seems relatively small—the bibliography of von Baer is six times as great—but this is explained by the fact that the papers are mainly of a critical character and are the fruit of intricate and time-consuming studies, just as von Baer's 'Entwicklungsgeschichte der Thiere' was the outcome of no less than nine years' of assiduous labor.

The writings of von Kupffer deal in the main with problems in special fields of embryology. A number of his well-known papers are contributions to histology, and there are several dealing with craniology, including the memoirs on the skull of his illustrious predecessor in Königsberg, Immanuel Kant.

The histological work of von Kupffer extends over a wide range of subjects. To cytologists he is known as a pioneer in the study of the ultimate nature of protoplasm. Thus, according to Bütschli, he ranks as the first to demonstrate satisfactorily the reticulo-vesicular character of protoplasm in living tissue. His observations in 1870 in the follicle cells of Ascidia showed distinctly the reticular meshwork and the breaking up of the cytoplasm into ultimate 'vesicles.' He also indicated for the first time (1870) the radial arrangement of the alveoli around the nucleus, together with the 'marginal alveolar layer.' The term 'paraplasm' used by von Kupffer in 1875, is still in use (as the equivalent of what at present is more often known as 'metaplasm') although in a somewhat different sense than that in which it was first used. His sustained interest in this theme was lately shown in his inaugural address (1896) as rector of the University of Munich.

The processes of the fertilization of the egg have been described by him in several forms. In an early paper on this subject he expressed his belief that in large meroblastic eggs a process of physiological polyspermy occurs, a view which his student, Professor Rückert, and other investigators have since confirmed and extended. His studies on fertilization have thus been important as leading the way for other papers from his laboratory—such for example as those on the fertilization of the lamprey and of the teleost by his devoted friend, Dr. A. A. Böhm, and also the earlier work of Theodor Boveri.

Von Kupffer's work should next be noted in connection with the structure of glands. In his studies on the histology of the liver he proved the presence of the secreting vacuoles in the gland cells and of the intralobular fibrous sheath. He next discovered the remarkable Sternzellen (or 'Kupffer's cells') in the wall of the portal capillaries: these he showed were not nervous, as was at first believed, but highly modified endothelial cells, and later he demonstrated their function as phagocytes. His researches on the development of the mammalian kidney should here be mentioned: these he carried on by means of serial sections cut by free hand—this was long before the time when section cutting became general—and by this means he was able to demonstrate more satisfactorily than

had hitherto been done the early separation of the mesonephric from the metanephric kidney, and he first showed the essential relations of the permanent kidney and its ureter to the mesonephric duct.

Another of his histological works deals with the structure of the stomach, in this in a measure preparing a way for the exhaustive comparative studies of his student, Professor Oppel. Other contributions relate to the development of the liver, spleen and pancreas (in *Ammocoetes*) and afford striking evidence that these organs are closely related genetically. Further papers discuss the characters of muscle cells, and the origin of blood in the valves in the dorsal vessel of the leech (*Rhynchobdella*). In his earlier work he was also attracted into the puzzling field of the electric organs in fishes (*Gymnotus*, *Mormyrus* and *Malapterurus*).

Another and perhaps the most important line of his histological work relates to the structure of nerves. He thus demonstrated that the axis cylinder was not a solid structure in the sense of the earlier investigators. This condition he showed was artifact: the 'cylinder' is rather to be looked upon as an axial canal containing in its fluid contents the delicate fibrils. In the matter of the central origin of nerve fibers his further observations have yielded a basis of the new neurone theory. The difficult question as to the exact mode of termination of nerve cells in an end-organ he also successfully answered in one of his earlier papers; in the salivary gland (*Blatta*) he was able to trace the final arborescence of the nerve filaments on the wall of the gland cell and he described the discoidal enlargement at the tip of each fibril.

Von Kupffer had never played the rôle of a pioneer in any extended field of embryological research. He has done the work—which has only too often the greater value—of extending, correcting and interpreting the results of earlier observers. Thus his famous work on the development of the Ascidian was in the path which had been opened by Kowalewsky, whose results, as von Kupffer himself notes, were then almost universally discredited. Von Kupffer soon came to support the new cause and he even outdid Kowalewsky himself in advocating the closer affinities of the ascidians and chordates. He thus showed in the ascidian the continuity of the cord and brain, the 'segmentation' of the tail, the presence of 'spinal nerves,' and the distinctly chordate character of the notochord, together, later, with interesting homologies in the sense organs. And so too in his extended paper on the development of the Lamprey he took up the unfinished work, and succeeded in reconciling several discrepancies in the results of Max. Schultze and Shipley. But it should be understood that the results of pioneer investigators were to von Kupffer but as the foundation stones of detailed and original work. Thus in his paper on the lamprey he soon laid aside his purely critical studies and attacked a series of difficult problems relating to the origin of the mouth, the cranial nerves, and of the primitive conditions of the central nervous system.

Gastrulation is one of the most difficult processes with which the student of the development of vertebrates has to deal. And it is upon this theme that the work of von Kupffer has thrown no little light. It was formerly thought—and this was the rock which wrecked the results of Pander, Baer, and Rathke—that in the large yolk-filled eggs of such animals as reptiles and birds the germ-layers of the embryo arise one from the other by a process of splitting (delamination). Von Kupffer, however, was able to demonstrate that in these forms a process of infolding occurs, modified, it is true, but proving that the gastrulation of the higher forms is clearly homologous with that of the amphibia and many fishes.

He was also the first to give a satisfactory interpretation to a characteristic structure of the gastrulation of the meroblastic types, the primitive streak. An especially remarkable feature of von Kupffer's work was that he made his interpretation of the invaginate character of the early gastrula of a meroblastic type in his study of the teleost—a form in which the appearance of the infolding process is so difficult to observe that his early results were for thirty years discredited—and it is only recently that the 'prostoma' in these forms is again described (Sumner). It was his earliest paper on teleostean development, by the way (Ref. No. 6, II.), which describes 'Kupffer's vesicle,' which in the matters of its homology and function has since been an unusually fruitful theme for controversy. We may note in passing that von Kupffer believed that the region of the prostoma was (as he also interpreted the primitive streak of amniotes) the *only* region of gastrulation in the bony-fish, that he failed to determine the invaginate character of the germ ring, and that he interpreted the early embryo as equivalent to the primitive streak, and not therefore to the actual embryo.

In connection with Kupffer's work on the development of the teleosts it should be mentioned that it is he who deserves the credit for the view that the cells of the blastoderm are the progenitors of the periblast nuclei, and that they also give rise to the tissue cells of the embryo, questions of great theoretical importance. His work on the development of the herring, undertaken in the interest of the Commission for the Investigation of the Fisheries of the German Ocean, is a further memorable contribution to the biology of fishes. Here for the first time in any extended embryological memoir photo-micrographs were introduced as plates.

Only a tithe of von Kupffer's publications relate to the development of mammals. His most noteworthy paper deals with the question of the 'inversion of the germ layers' which had been described in a rodents, a condition which appeared to be an extraordinary contradiction to the usual mode of origin of the germ layers. By means of a series of stages of the field-mouse he showed conclusively, however, that this 'inversion' was only apparent: during early growth the embryonic area bowed downward to the ventral side of the ovum, so that the flattened gut came to be apposed to the surface while the central nervous system was left to develop within the cavity of the ovum.

The philosophy of the vertebrate head has furnished the fruitful theme of von Kupffer's studies during the past ten years. And his memoirs (three of the series have thus far appeared) upon this subject are, I think, regarded generally as his *magnum opus*. His endeavor in these memoirs is to demonstrate by ontogenetic conditions in the lowest craniotes the mode of origin, phylogenetic, of the structures of the vertebrate head—brain, cranial nerves, sense organs, mouth region, muscles and skeleton. The plan of this series accordingly recalls somewhat that of Dohrn in his 'Urgeschichte der Wirbeltiere,' although the views of their authors are usually widely at variance. Von Kupffer derives the ground plan of the conditions of the vertebrate head from that in the protochordates while Dohrn, for a long time, at least, has been the strong supporter of the famous annelid theory. Certain it is that the results of von Kupffer are welcomed by the warmest interest even by those whose faith in the great value of developmental characters as tests of phylogeny has been severely shaken. And all will admit he has already been able to clear up a number of doubtful points in cranial problems: thus, to mention but an instance or two of the general value of his work, it is now

found possible to determine definitely the most anterior point of the brain and to compare with certainty—thanks to his revision of topography—such widely distinct and important regions as those of the lobus olfactorius impar, the recessus opticus and the tuberculum posterius, in all chordates from amphioxus to man. So, too, his determination of the metameral characters and subdivisions of the cranial nerves bids fair to become a classic if not an epoch-making contribution to the philosophical side of this long investgated and difficult subject.

In a late number of the Münchener Medicinische Wochenschrift, Professor Rückert* pays a tribute to von Kupffer's remarkable power of continuing and improving the quality of his work in spite of the burden of seventy years, and he concludes his paper with the wish that von Kupffer will long be spared to continue his good work. In this wish his American colleagues heartily join.

Bashford Dean.

The following bibliography of von Kupffer is largely due to the kindness of my friend, Dr. L. Neumeyer, of the Anatomical Institute in Munich.

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*RECENT PROGRESS IN GEODESY.**

THIS report is not based upon a complete examination of the recent literature of geodesy. The writer has been too busy to devote much time to the special research necessary to justify any claim to completeness. His regular duties have, however, kept him in touch with recent operations in geodesy, much more closely in touch, however, with operations in the United States than with those of Europe. The sketches of recent progress in each of several sciences called for by the rules of the Society are, as I conceive, to be written primarily, not for those well versed in that particular

*Forming a part of the Report of the Standing Committee on Mathematical Science for 1899. (Read before the Philosophical Society of Washington, February 3, 1900.)

science, but for the general information of others working on other lines. To this end a bird's-eye view of the present state of the particular science, together with a statement of the more important and interesting recent developments, will serve better than a detailed catalogue of the separate steps which make up recent progress.

By studying the recent reports of the International Geodetic Association and the geodetic reports from various countries, one is gradually convinced that there is well-sustained activity in geodetic operations in many countries, that geodetic facts are being steadily accumulated, and that steady progress is being made in improving methods and instruments. Having realized this, one naturally looks for published collections of results, and for some reasonably complete and well-digested scientific papers showing the relation between existing theories and results. One expects to find a considerable portion of the accumulated facts published in convenient form for the use of the hydrographer, topographer, the physicist, and the engineer. But this expectation is not realized. Of the great store of accumulated facts only a small part are as yet published in any complete or systematic way. The remaining ones are published, if at all, in such a fragmentary and disconnected form as to lose much of the value which they would otherwise have. Again, one looks in vain for any comprehensive study in recent years of the earth's figure and size. Since the publication by Colonel Clarke, some twenty years ago, of his values for the polar and equatorial radii, no corresponding comprehensive investigation has appeared in print.

It is not easy to understand why publication and discussion should lag so far behind the measures in the field. One consideration presents itself, however, as a partial, though insufficient, explanation. To adjust a network of triangulation requires an amount of expert computing which, as to time and cost, seems disproportionate to the field-work. Consequently, there is a decided tendency for the computations to be several years behind the corresponding field operations. By the time computations are finished for a given area new results of observations are available in that area or in adjacent connecting areas. Thus it always seems that the time for publication has not come, since whatever might be published would of necessity be incomplete.

It may be admitted that in many cases the computations made have been more complex and laborious than was warranted by the observations. The problem is one which lends itself to many theoretic refinements leading to long computations.

In what is above written as to delays in publication and computations needlessly prolix the writer must not be understood as referring chiefly to work in United States. Publication is apparently no further behind in this country than in other countries, with the possible exception of Great Britain. In simplifying the computations in office to correspond with the accuracy attained in the field, this country is easily foremost.

The years 1898 and 1899 mark an epoch in the history of geodesy in the United States. In 1898 the last of the field operations on the great transcontinental arc, extending from the Atlantic to the Pacific along the thirty-ninth parallel, were completed. During the same year the field measures of the oblique arc parallel to the Atlantic coast were also completed. In 1899 the necessary observations to complete an oblique arc in California, extending from Point Arena to the Mexican boundary, were brought to a close. In 1899 also, but little more than a year after the completion of the last field measurements, the computations connected with the arc of the thirty-ninth parallel were completed and the results put in form for the printer.

To appreciate the full force of the above statements one must have a realizing sense of the great length of the above arcs. The combined length of all the arcs used by Colonel Clarke in 1880 to deduce the figure of the earth was equivalent to 89 degrees of a great circle. The arc of the thirty-ninth parallel is equivalent in length to 37 degrees of a great circle; the Atlantic oblique arc is 22 degrees long, and the California oblique arc 8 degrees; and the combined length of these three arcs is 67 degrees, or more than two-thirds the total length used by Clarke.

The most interesting recent development in geodesy has been the investigations of variations of latitude. It may be asked, "Why is this investigation classed as geodetic rather than astronomic?" The answer is: It belongs in both classifications. Obviously it is an astronomical investigation, but it concerns the geodesist also; it concerns him directly, because the astronomical latitudes with which he must deal are now known to be a function of the time of observation. It is interesting to note also that many of the observations upon which our knowledge of the latitude variation depends were made with the zenith telescope, an instrument which the geodesist claims rather than the astronomer.

For ten years past there has been marked activity in investigating this question along two lines. One class of investigators worked by the inductive method, and slowly built up empirical mathematical expressions for the observed facts as to the variations, independently of any theory as to their causes. For this purpose they used many series of old observations, made at various fixed observatories, but not primarily for this purpose. In addition they have used many modern series of observations, made with zenith telescopes, for this special purpose. It has been shown that the motion of the pole in the past may be represented with considerable accuracy as a combination of two motions, each circular, one with a mean period of about 428 days and the other with a period of one year. A still closer approximation is obtained by assuming that the amplitude and epoch of each these motions is subject to a periodic variation. A somewhat closer agreement between the mathematical curves and the observations is secured when elliptical paths are substituted for the circular paths above referred to. The net result of the investigations by the inductive method has been certain mathematical expressions which closely represent the known facts of the past, but there is great uncertainty as to how far into the future these mathematical expressions may be extended, because their basis is wholly empirical.

The progress made along this empirical line of investigation has been due to Professor S. C. Chandler, of Harvard, more than to any other one man or, possibly, any group of men. His results have been published as the investigations proceeded in the *Astronomical Journal*, and form an exceedingly interesting series, not only on account of the remarkable success attained, but because of the ingenuity and skill shown in devising methods of investigation which are independent of any theoretical basis.

Another class of investigators has worked from the standpoint of pure theory. Their endeavor has been to furnish an adequate explanation for the observed facts. Up to the time when the latitude was shown, by direct observation, to be subject to periodic variations, one of the fundamental assumptions upon which astronomical computations were based was that the latitude of a given point on the earth's surface is invariable. Pure theory, indeed, indicated that the latitude of a point should be subject to a periodic variation of small amplitude with a period of about 305 days. Special inves-

tigations had failed to reveal a variation having that period, and astronomers had fallen back to the dogma of invariability. Theorists are now confronted with the necessity of accounting for a period of about 428 days instead of 305. It is known that any movements of the earth's crust and of the water and air in response to a displacement of the pole of figure from the pole of rotation have the effect of lengthening Euler's period. It has been shown that any difference in the equatorial radii also has a tendency to increase the theoretical period to correspond more nearly with the fact. The known atmospheric and oceanic currents have also been appealed to for an explanation. It has also been shown that it is not impossible that such impulsive forces as are concerned in earthquakes and volcanoes may produce some of the effects observed. The net result, however, of the investigations of theorists has been a series of partial explanations, no one of which stands all the tests which have been applied to it. Each fails, either by furnishing a law of motion which differs essentially from the observed facts or by being quantitatively inadequate.

This was the situation when the International Geodetic Association formulated and adopted a plan for determining the actual motion of the pole during a series of years with the highest attainable accuracy. The observations, in conformity with the plan devised by them, were actually begun in the latter part of 1899, and it is proposed to continue these observations uninterruptedly for at least five years. The plan of operations is that the actual motion of the pole shall be determined by simultaneous observations at four stations widely separated in longitude, at each of which an instrument of the highest precision is to be so used as to guard, as fully as possible, against all known sources of systematic error. The details of the plan have been worked out very carefully, and it is admirable in every respect.

The four stations selected are Gaithersburg, in Maryland, in longitude + 77; Ukiah, California, in longitude + 123; Mizusawa, in Japan, in longitude + 219, and Carloforte, on the small island of San Pietro, just west of Sardinia, in longitude + 351. One of these stations occurs in each of the four quadrants of longitude, reckoned from Greenwich. All are within three seconds of the parallel of 39 ° 8′ 10″. The conditions considered in selecting them, other than those indicated above, were that there should be nearly symmetrical conditions as to the character of the surface northward and southward of the station to avoid unsymmetrical refraction; that the hygienic, social, and climatic conditions should be such that the observer might remain healthy, comfortable, and contented; and finally in Japan and at the European station the region was carefully studied with reference to the probable frequency of earthquakes.

Two extra volunteer stations have now been added to these four, one at the Cincinnati observatory, which happens to be nearly on the parallel of the four selected stations, and one at Tschardjiu, in Turkestan.

The four principal observatories have been constructed with the utmost care, under specifications furnished by the International Geodetic Association, specifications designed to insure that observations shall not be vitiated by local differences of temperature. The observatory proper is surrounded by lattice-work to protect it from direct sunlight and the roof is double. During observations the roof is rolled back to leave an observing slit two meters wide. The walls are so low that the telescope projects above the roof during observations. This fact, together with the unusual width of the observing slit, puts the instrument virtually in the open air during observations.

The instruments used at the principal stations are specially designed zenith telescopes, by Wanschaff, of Berlin. The telescope has a focal length of about 51 inches, an aperture of 4¼ inches, and a magnifying power of 104. Aside from other minor peculiarities, two are especially noticeable. The barrel of the telescope proper is protected by an outer thin metallic tube, which is connected at but few points with the telescope proper, and serves merely to protect it against sudden changes of temperature. This false tube is pierced at various points to permit circulation of air in the space between it and the tube proper. The eyepiece is furnished with a reversing prism of peculiar construction, such that all observations may be made with the observing line apparently vertical and with the star apparently moving either upward or downward at the will of the observer. The observation upon one star consists of four pointings, two taken while the star is moving apparently upward in the field of view and two with the star moving apparently downward, the reversing prism being turned 180 degrees between these observations. If, then, the observer has a personal tendency to place the observing line too far to the right, this will have contrary effects in the two pairs of bisections, and the personal equation will be eliminated from the mean result. In so far as accidental errors are concerned, the few observations already made indicate a high degree of accuracy, the probable error of a single observation of a pair being about $\pm 0''.10$. Few series of observations yet made can show probable errors as small as $\pm 0''.16$.

The computed motion of the pole will be nearly independent of the errors in the assigned declinations of the stars, the effects of the errors of declinations being eliminated by the well-known group method. The stars to be observed are divided into twelve groups, and each group is observed for about two months (50 to 80 days, according to the time of year). During the first half of the period when group No. 2 is being observed group No. 1 is also being observed, and during the latter half of the period group No. 3 is being observed at the same time as group No. 2. Similarly, group No. 3 is observed first in connection with No. 2, and then in connection with group No. 4, and so on. The difference between the mean latitude from group No. 1 and the mean from group No. 2 during the period when both groups are being observed is obviously due to the difference of the mean error in declination of the stars of the two groups and to accidental errors of observation. This method of observation, after being extended throughout the whole cycle until group No. 12 overlaps group No. 1, furnishes a means of determining the declination correction to each group to reduce it to the mean of all the groups, and thus to eliminate the declination errors from the computed change in latitude.

As an additional precaution, the same list of stars is to be observed at all the stations.

The effect of an error in the assigned proper motions of the stars observed will be to make the latitude of any one station appear to increase or decrease with lapse of time, but will have no appreciable effect on the value finally derived for the motion of the pole; for, the same list being used at all stations, all the latitudes will appear to increase or decrease together. Both the Japan and the Maryland station, would appear, say, to have increasing latitudes, although they are nearly on opposite sides of the pole, and therefore this result could not be mistaken for an actual motion of the pole.

Aside from the precautions already indicated against abnormal refractions due to local conditions, the observations themselves have been planned so as to guard against

greatest depths, a fauna, not very abundant to be sure, but of great interest because of the strange peculiarities of some of the forms. With others I was profoundly interested in this work, and it lead me to conjecture whether there was not a field for investigation in the deeper waters of our lakes. At that time very little had been done in the way of any systematic study of the deeper waters of the lakes. I think the only extensive work on the subject was Forel's 'La faune profonde des lacs Suisses,' published in 1885. Professor Forel had begun his researches on the deep water fauna of Lake Leman in 1869, and had published various notices in the intervening years. In this country, so far as I know, the first publication in regard to the deep water fauna of lakes was in the first volume of the *Transactions of the Wisconsin Academy*, in a paper by Dr. Hoy, of Racine. He detailed how he had become interested in the food of the whitefish, and had examined their stomachs, finding certain animals that seemed new to science. A company was made up for a dredging expedition consisting of Dr. Hoy, Dr. Lapham, Professor Stimpson, Professor Andrews and Mr. Blatchford, and put in a day's work dredging on Lake Michigan in June, 1870. The result was the collection of a considerable number of animals. Especial importance was attached to the discovery of a *Triglopsis* and a *Mysis*, as they are marine genera, and their presence was supposed to indicate a former direct connection of Lake Michigan with the ocean.

In 1874 Professor Smith published a paper on the 'Invertebrate Fauna of Lake Superior,' reporting the existence of the same crustacea in Lake Superior which Dr. Hoy had found in Lake Michigan. The *Mysis* there, however, occurs in somewhat shallow water as well as in the greater depths. In both lakes it forms an important—perhaps the most important—constituent of the food of the white fish and lake trout. As I was located near a lake of considerable depth, a depth reputed to be anywhere between 400 feet and infinity, it occurred to me that I had an opportunity to carry out similar researches.

My own work on lakes, then, originated in a desire to know more about the abyssal animals. I soon found, however, that the problem was a serious and complicated one, involving a complete faunistic study of the lake. I was fortunate in finding on the bottom of Green Lake the same *Mysis*, which makes its home in Lake Michigan. These animals have not been definitely reported from any other lake in the United States, although *Mysis* is said to live in a lake in New York connected with the St. Lawrence. Here was a pretty problem in animal distribution. How did these animals make their way into Green Lake? Was it by way of the Great Lakes, or did they come at some time by a connection through the Mississippi Valley? I could not tell, and I cannot to-day, for it becomes a problem for the geologist rather than the zoologist. With this as a starting point I attacked the problem of lake faunæ, and the battle is still in progress with no indications of a conclusion of hostilities for many years to come.

During the decade in which I have been interested in limnology there has been a very considerable advance in our knowledge of the subject, and it will be my attempt to night to summarize this knowledge, and make as clear a statement as I can in the brief time at my disposal of what is now known of the fauna and flora of fresh water lakes. Russell, in his work on North American Lakes, enumerates ten agencies which, acting separately or in combination, may produce lakes. So far as our Wisconsin lakes are concerned, the most important of these agencies is glacial action. Most of our lakes are simply the depressions caused

errors arising from this cause. Each group contains six pairs which are used directly for computing the latitude variation, and of which very few have zenith distances exceeding 20 degrees. Each group also contains two pairs introduced for the special purpose of studying the actual refraction, and of which the zenith distance is about 60 degrees. The normal refraction at a zenith distance of 60 degrees is about four times that at 20 degrees; hence the two refraction pairs will furnish an effective method of determining any peculiarities of refraction which are sufficiently great to produce any appreciable effect upon the latitude pairs, provided such effect is one which increases with the zenith distance.

Any refraction effect which is analogous to a displacement of the apparent zenith, by a persistent barometric gradient, for example, will not be put in evidence by this test. To eliminate such an error, dependence is placed upon the fact that the final result is based upon observations at several stations varying greatly in longitude and in the surrounding climatic and local conditions.

It may seem at first sight that an annual variation in refraction would produce an apparent annual motion of the pole. This would be true if the motion of the pole were derived from observations at one station only. It will be seen, however, on further reflection that annual variations in refraction would tend to make all the latitudes along one parallel apparently increase and decrease together, and that therefore the computed motion of the pole would not be appreciably affected if these annual variations were of about the same magnitude at the different stations distributed around the pole.

To sum up, the discovery of the periodic motions of the pole was first made by a purely inductive method. The laws governing those motions have been slowly and painfully deduced by a continual application of the same method to old series of observations and to many new series made for the special purpose. Now a new campaign of observations, promising results more accurate than any hitherto obtained, has been commenced. The mean position of the pole for each fortnight of the next five years will probably be known within a radius of five feet. There is little prospect for improvement of the observational side of this question for many years. The new observations will furnish material for new triumphs of the inductive method in furnishing a still closer mathematical approximation to the unknown laws of motion of the pole. The interesting feature of this investigation is now that the theorists are at sea, so to speak. Will they at the end of the five years be able to furnish an adequate explanation for the new facts observed or, indeed, for those already known? It is on this theoretical side of the investigation that new energy is needed. Here is a golden opportunity for some one well versed in mechanics, astronomy, and geodesy.

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U. S. Coast and Geodetic Survey.

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*THE PLANKTON OF FRESH WATER LAKES.**

For some years I have been interested in the subject of the fauna of our fresh water lakes. This interest was first aroused in regard to the animals of the deeper parts of the lakes. The results of the explorations of the depths of the ocean were just becoming known. I had read in the older works that while the sea was densely populated along shore, and had what has become to be known as a 'pelagic' fauna and flora in the open sea, remote from land, the depths were a barren region utterly devoid of both animal and vegetable life. But later it had been shown that there was, even in the

* Address of the retiring President of the Wisconsin Academy of Sciences, Arts and Letters.

crustacea may be said to date back only half a century to the writings of Fischer and Claus, although some papers upon this subject had been published previously.

In 1817 Say published a somewhat extended article on the crustacea of the United States, in which he speaks of one *Ostracod*, two *Daphnias* and one *Cyclops*, as inhabiting the waters of the southern states. In 1843, in the 'Natural History of New York,' was published an article by DeKay on the crustacea, which was beautifully illustrated, but added little to our knowledge of the fresh water crustacea. In fact, though *Cyclops* and *Daphnia* are mentioned, they are spoken of as 'extra-limital,' in spite of the fact that not a lake in New York would have failed to furnish him countless numbers of these genera, had he looked for them. To Professor Forbes, of the University of Illinois, is due the credit of making the first extensive collections of these animals in this country, and publishing accurate descriptions of them. His first paper was published in 1876, and was followed by a series of very valuable investigations, culminating within the last few years in the establishment of a floating laboratory on the Illinois River for the continued study of the fauna and flora of that river and the shallow lakes adjoining.

In Europe large numbers of investigators within the last few years have devoted themselves to the study of fresh water animals and plants. Preëminent among them have been Forel and his co-laborers on Lake Leman, and Zacharias and his fellow-workers in the station at Lake Plön in Holstein. This station at Plön was, I believe, the first permanent fresh water station in the world. Since its establishment in 1891, a considerable number of permanent stations have been established in various parts of the world. It is not my purpose here to give a history of these establishments, for that has already been exceedingly well done by Professor Ward. I may call attention in passing, however, to the fact that the work in this country has been done almost exclusively in our immediate vicinity, Illinois, Wisconsin and Michigan having published by far the most material on this subject. Similar work has been prosecuted in Minnesota, Ohio and Indiana, but very little has been done in the other states, if we except the exceedingly valuable work of Whipple.

In Wisconsin, work has been prosecuted on the Madison lakes and Green Lake for many years, and now, under the auspices of the Natural History Survey, a more extensive and systematic biological survey of the lakes is being made, probably a more extensive comparative study than has been attempted elsewhere. While this study is of especial scientific interest, as has been intimated before, it is of great practical interest in connection with the problems of fish culture. It may not be likely that, as suggested by a recent writer in *Forest and Stream*, the future angler will carry with him a thermometer and chart with a statement of the laws of vertical and horizontal distribution, but such study does give a fundamental knowledge which is of vast importance to the angler as well as to the fish culturist.

The terminology used in the study of the fauna and flora of fresh-water lakes, as in the sea, was formulated by Häckel. Under the term 'plankton' is included all living things, animal or vegetable, found in the water which do not move from place to place by their own volition. Fishes are not considered a part of the plankton. The life of the sea may be considered as 'littoral,' 'pelagic' and 'abyssal.' To these terms Häckel adds 'zonary,' to include those animals which are supposed to occur at zones of different depths in the open ocean. In the littoral and pelagic planktons we may have both animals and plants, but in the abyssal

by the unequal distribution of the glacial drift, or by interference with preëxisting drainage lines. Inasmuch as Wisconsin is not a mountainous state, it follows that these depressions are nowhere of great depth, and that we have no lakes which compare in depth with those located in mountainous regions. Most of our lakes are extremely shallow, few being more than forty or fifty feet in depth. Lake Geneva 142 feet, and Green Lake 237 feet, are our deepest bodies of water, while our largest lake, Lake Winnebago, probably does not exceed twenty-five feet. All lakes are temporary features of the topography. The outflowing water is all the time deepening the outlet and increasing the amount of drainage, while the inflowing water is bringing in material which gradually fills up the lake bed. This process goes on with comparative rapidity, and even in our new lake areas there are numerous examples of dead lakes where swamp vegetation entirely covers what was formerly an open sheet of water. The physical processes involved in the lives of lakes and the relation of the lake vegetation to these processes are very interesting, but this is not the time or place to discuss them, and they can only be referred to in passing.

The subject of the fauna of fresh water lakes has not been especially attractive to zoologists. This is but natural when we consider the great wealth of life in the ocean, and the comparative poverty of fresh water. Of the more important divisions of the animal kingdom the echinoderms and tunicates are entirely absent in fresh water, and the cœlenterates and molluscoidea are represented by few forms. Even the crustacea, which form the greater part of the plankton, and are present in such enormous numbers, have very few forms compared with the crustacea of the sea. It is to be expected that zoologists will be attracted by this wealth of material in the sea, and that most of them will in the future as in the past resort to the sea for their study. It was in the ocean that the ancestors of our fresh water animals dwelt, and it is amongst those animals that the student may expect to find the most information in regard to the development of life on the earth.

But the lakes have their fauna, a fauna of great numbers if not of great variety, and because of their isolation and somewhat peculiar conditions, present a very interesting study in the distribution of animals. Of course the best known members of this fauna are the fishes, whose numbers, habits, and food are fairly well known. Fish are so important for human food that a study of their habits comes to be a matter of commercial importance, and our Federal and State governments expend large sums of money for this investigation and for the practical work of rearing and distributing the spawn or young fish. In Wisconsin, too, as well as in some of the other northern States, it is a matter of great practical importance to maintain the numbers of game fish in our lakes simply for the purposes of sport. Until one has made the rounds of the summer resort lakes one has little idea of the multitudes of people who come to our State in the summer season, attracted largely by the opportunities for fishing. Hundreds of thousands of dollars are brought to us every summer in this way, and it is a good business policy which leads us to do all in our power, and even spend large sums of money, if necessary, to maintain our stocks of game fish.

It has long been known, of course, that fish are dependent for their food upon smaller animals, and it has also been known that a knowledge of these same small animals was necessary to any accurate and complete knowledge of fish, but this study was so difficult and involved so much drudgery that for a long time it was neglected.

Anything like an exact knowledge of the

these are an enormous number of diatoms. *Chlorophyceæ* are present in larger or smaller numbers and sometimes large numbers of the *Cyanophyceæ*. Generally speaking the limnetic flora is not sufficiently abundant to attract attention, but on some lakes they are sometimes multiplied in such quantity as not only to attract attention but even to excite alarm. The surface of the lake has a thick coat of bright green, and as this is cast up on the shore by the waves it forms thick ridges which in their decay become very offensive. This phenomenon has been known in England as 'the breaking of the meres,' in Germany as the 'wasserblüthe,' and in this country as the 'working of the lakes.' The appearance is sometimes ascribed to the seeds of littoral plants. Only a few species of plants are concerned in this phenomenon, and the species differ somewhat in different lakes. Certain diatoms may be present, too, in sufficient numbers to produce an unpleasant 'fishy' smell in the water. This exaggerated growth of the limnetic flora is most pronounced in shallow or comparatively shallow lakes, and is frequently a source of great annoyance to cities which get their water supplies from such bodies.

The limnetic fauna, as I have said before in this address, has but few kinds of animals, by far the most numerous and characteristic being the crustacea. These are beautiful, transparent and nearly colorless creatures. It is not true, as is sometimes stated, that the limnetic fauna is entirely distinct from the littoral. The general character of the limnetic animals is certainly different, and distinctly different, from that of those found in the littoral region, but many individuals are common to both. It is true, however, that while there is hardly a radical distinction between the two faunæ, certain species are common in the limnetic regions and only rarely found in the littoral, while some that are everywhere in littoral collections are rarely found in those taken in the open water. There is, of course, no clear dividing line between the two regions, but one insensibly merges into the other, while, under the influence of the winds and waves, such limits as exist are continually changing.

In the species of crustacea there is a certain distinction between the limnetic fauna of the deeper lakes and that of the shallower. One species of *Diaptomus* is found everywhere in the Great Lakes, but in only three of the Wisconsin lakes—Lake Geneva, Green Lake, and Cedar Lake. The shallowest of these lakes—Cedar Lake—is about a hundred feet in depth. One of the species of *Cyclops* is very abundant in the Great Lakes, but is seldom found elsewhere except in comparatively deep lakes.

In a paper published in the Transactions of the Academy, I made the suggestion that lakes might be divided according to their faunæ into the deep water and the shallow water, suggesting as a possible limit between the two 40 meters. I have since found that Elhart Lake, 117 feet, and Cedar Lake, 95 feet, have many characteristics of the deep water fauna, and it is possible that the dividing line should be nearer 30 meters than 40.

The German authors make a distinction between 'plankton-poor' and 'plankton-rich' lakes, which very nearly corresponds to my deep-water and shallow-water lakes; for the total amount of plankton in the deep lakes is very much less than in the shallow lakes. This is easily explained. For the number of animals is, of course, dependent on the number of plants. Inasmuch as plants are dependent upon sunshine, they will grow in water only in those places that are reached by the sun's light. As the light of the sun penetrates in deep water only to a limited distance, the deeper parts of our lakes are entirely de-

no plants are found. The study of the pelagic and abyssal faunas has been entirely within the last half century; in fact the very knowledge of their existence dates back hardly fifty years.

In the lakes we use a similar set of terms. The regions are 'littoral,' 'limnetic' and 'abyssal.' The characteristics of these regions are somewhat known, but still our knowledge is far from perfect.

A list of the plants and animals found in any one lake seems quite formidable because of its length, but the species that are present in any considerable numbers are very few. From a limnetic collection, for instance, we may find in abundance the following: Four or five copepods, five or six cladocera, three or four protozoa, and perhaps two rotifers. This would be a fair average fauna in one of our lakes. Of the plants, we would find two or three diatoms and as many algæ.

Not only are the animals and plants of neighboring lakes very much alike, but the same animals may be found distributed over wide territories, and even over different continents. This is true even of some of the higher animals of the plankton, like the crustacea. Of our fifteen species of *Cyclops* nine are found in Europe. In the case of one species it is not only found in Europe, but in Asia and in Africa, and literally does not vary a hair in these widely separated localities. On the other hand, the genus *Diaptomus* is very variable. We have not a single species which is common to the European lakes. Not only that, but there are many localized species in the United States. One species occurs, so far as known, only in a few lakes in the northern part of the lower peninsula of Michigan. A second is widely distributed in all the smaller lakes across the continent in the northern States. Another goes from the center of Wisconsin north into the Arctic regions. In the Rocky mountain regions are several peculiar species. Through the southern States two species are found which never come north. Mexico has at least one peculiar species. Of the other organisms, both animal and plant, most are world-wide in their distribution. From this fact of the general uniformity of fauna and flora over wide regions, it is clear that the study of a lake which simply produces a faunal and floral list is of very little value. There was a time when such lists were important, before this uniformity of distribution was determined, but that time is long since past, and those European authors who continue to fill the proceedings of learned societies with lists resulting from desultory explorations of one or more lakes are almost wasting printers' ink.

In the littoral region we find usually an abundant flora. Those plants which need an anchorage find it in the mud of the bottom, and the unattached plants are protected by those that are stationary. Protected by these plants and living upon them is an abundant fauna in which crustacea are the most prominent, although we find great numbers of rhizopods, infusoria, sponges, hydrozoa, worms, true insects and mites, mollusca and bryozoa. This abundance of the lower animals forms a rich supply of food upon which the higher animals can live. It is in this littoral region that the fish get the most of their food, and every fisherman knows that marshy borders are necessary to maintain the supply of fish. The animals of the littoral plankton are opaque, and generally are so colored that when they are at rest they are inconspicuous. Those that swim about and then drop to the bottom to rest are ordinarily so colored that they are not easily distinguished from the mud. Frequently in littoral regions the bottom is covered with a thick mat of *Chara*, which, in turn, forms hiding places for enormous numbers of the invertebrates.

The flora of the limnetic region can be, of course, only of floating plants. Among

void of plant life. On the other hand in shallow lakes not only do we find the floating vegetation as in the deep lakes, but as the light reaches the bottom over a larger proportion of its surface, we have in addition a very large flora flourishing on the bottom. In some of the very shallow lakes nearly the whole bottom is covered with a rank vegetation. This is true, for instance, of Lake Vieux Desert. In Green Lake, on the other hand, inasmuch as the shores are somewhat precipitous, there is only a comparatively narrow margin on which can be supported a flora growing upon the bottom, while the larger part of the lake is so deep that only the floating vegetation can exist. It is easily seen, then, that a shallow lake will be 'plankton-rich' as compared with a deep lake. Fishermen recognize this fact, and expect the shallow lakes to be better for their sport.

It is evident, then, that the living limnetic vegetation must be at or near the surface, where it can have an abundance of light. Animal life, however, is not limited in this way. It was long ago shown that in the sea there was an abundant surface fauna and an abyssal fauna, but in regard to the condition of the intermediate region there has been some dispute. Agassiz has claimed that there is a region intermediate between the top and bottom, which is entirely devoid of life. This has been disputed by some authors, and late explorations seem to indicate that no region between the surface and bottom is entirely free from animals. A similar condition exists in the lakes. By far the most abundant fauna is at and near the surface, but animals are found in greater or less numbers at all depths. The larger part of the plankton is found within thirty or forty feet of the surface; but the same kinds of animals that form the fauna of the upper waters may be found at all depths, although in small numbers. *Limnocalanus* is an example of an animal which belongs to the intermediate regions. It, too, may be found in small numbers at any depth from the surface down, but it seldoms occurs in any considerable numbers outside the intermediate region.

Limnocalanus and *Daphnia pulicaria* are perhaps the only animals in fresh water which belong distinctively to the zonary plankton, although *Cyclops brevispinosus* is much more abundant between five and twenty meters than it is near the surface.

Collectors of plankton material have known that they could ordinarily make much more abundant collections at night than in the daytime. This has led to a belief that there is a vertical migration of the plankton, towards the surface at night, and away from it in the daytime. It was supposed that the whole body of the plankton moved up and down. This idea has been proved to be false. What movement there is is within quite narrow limits near the surface, and all members of the limnetic fauna do not, by any means, behave in the same way. They have most decided individual peculiarities, so that we cannot speak of the movements of the fauna as a whole, but each species must be considered by itself. Some of them do not move at all vertically, but have the same distribution from one end of the day to another. Others, like the larval forms of the copepods, are more numerous at the surface in the daytime than in the night. Some have a very pronounced migration. This is particularly true of *Leptodora* which is rarely found at the surface in the daytime, but appears at almost exactly forty-five minutes after sunset, remains at the surface during the night, and disappears again at just three-quarters of an hour before sunrise.

Most of the larger crustacea which form the great body of the plankton do migrate in this way, and it was natural, perhaps, to

infer that the whole plankton moved up and down.

The limits of this vertical migration it is very difficult if not impossible to fix. Most of the movement is within one meter of the surface, the most marked changes being within one-half meter of the surface, and below three meters the amount of movement is very slight. Eight determining factors have been listed by Professor Birge as controlling the vertical distribution of crustacea: food, temperature, condition of the water in respect to dissolved oxygen and other substances, light, wind, gravity, age and specific peculiarities. Of these factors, by far the most important are food, temperature and light. Inasmuch as the food supply is controlled by temperature and light, we may speak of these two factors as, in the main, controlling the vertical distribution of the limnetic plankton. Of these two factors, temperature is the most important, although light has a marked effect on many species. In the winter season when the waters of all the lakes are very nearly uniform in their temperature from top to bottom, the vertical distribution of the limnetic fauna is much more uniform than in summer.

In the summer season the most marked changes in vertical distribution are correlated with the vertical changes in temperature. This is most distinctly seen in the deeper lakes. In these lakes it is a surface layer of greater or less depth which is warmed, the deeper layers feeling the effect of the summer's sun only very slightly. In Green Lake below 40 or 45 meters the temperature never rises above 6.11 degrees Centigrade, although the surface may run as high as 26.67 degrees C. In Lake Michigan the bottom temperature at depths of 360 feet is 4.2 degrees C., with a surface temperature of 18.3 C.

The change in the temperature from the top to the bottom is not a gradually decreasing one, however. A layer of water at the surface, which may be in midsummer some ten or twelve meters in depth, is very nearly uniform in temperature. From the lower surface of this layer there is a very rapid decrease in temperature for a short distance, and then a gradual decrease until a minimum is reached. This layer of sudden change in temperature is known as the 'thermocline,' and its position varies in depth with the season and the size of the lake. As the summer season progresses the thermocline grows lower. In the very shallow lakes the temperature during the summer season is nearly uniform through the whole depth. In Lake Winnebago, for example, there is seldom a difference between top and bottom temperatures greater than two degrees. In small lakes the thermocline is considerably higher than in large lakes. This is doubtless due to the influence of the winds, by which the small lake is less affected. This was very prettily illustrated in a comparison of the Waupaca lakes with Cedar Lake and Green Lake about August 1st of this last summer. In three of the Waupaca lakes—Rainbow, McCrossen and Beasley's, of which Rainbow is the largest and Beasley's the smallest, the thermocline was respectively at six meters, five meters and three meters. At the same time the thermocline of Cedar Lake was at eight meters, and the thermocline of Green Lake at eleven meters. The vertical distribution of the plankton has a very close relation to the thermocline, most of the animals being above it. *Limnocalanus*, *Daphnia longiremis* and *Daphnia pulicaria*, however, are found below the thermocline, and in some plankton-poor lakes the proportion of the other organisms below the thermocline is much larger.

It is evident that the circulation of the water is in the layer above the thermocline, and that below the thermocline there is insufficient oxygenation, and that this bottom layer must, too, hold a great deal of the

dead and decaying material falling from the upper layers. It is a curious fact, first pointed out, I think, by Whipple, that the bottom waters of deep lakes are stagnant during both winter and summer, but have a period of overturning in spring and fall. This overturning may come with considerable suddenness when the waters have not been much agitated by the winds. We ordinarily think that water is so mobile that the heavier portions will immediately sink, and thus the water of greater density will always be at the bottom. It may happen, however, as in the fall, that the upper waters will cool off, and yet retain their position, so that the lighter water will actually be below. The lake is in a condition of unstable equilibrium. If, under these circumstances, there comes a heavy wind, the whole body of water will overturn.

It is at these two periods of overturning, as shown by Whipple, that the growth of diatoms is especially pronounced, and they are found present in enormous numbers in the limnetic plankton. This great growth of diatoms is explained in the following way: During the periods of stagnation diatoms or their spores, if diatom spores exist, accumulate at the bottom of the lake, inasmuch as their specific gravity is greater than that of water. They do not grow there, because sunlight is essential to their growth. At the bottom is accumulating during this period, too, a large amount of organic matter from the decay of organisms near the surface, and this, under the influence of bacteria, is transformed into material fitted for food for the diatoms: in this food material the nitrates are perhaps the most important. When the time of overturning comes, the diatoms or their spores rise to the surface, accompanied by these dissolved organic materials, and, under the influence of sunlight, an exceedingly rapid multiplication takes place. As the food materials are used up the numbers of diatoms decrease again. Other organisms, of course, show the effect of the overturning of the water, for many are directly or indirectly dependent upon the diatoms for food, and, besides, diatoms are not the only organisms which can make use of the food materials which are thus brought to the surface. *Diaptomus, Epischura, Limnocalanus* and two species of *Cyclops* show quite clearly these two periods of rapid production, although in some of these cases the results are complicated by the fact that the temperature of the surface water has a direct effect on the reproduction.

The matter of the annual distribution of the organisms of the plankton is a very interesting question, but is also a very complicated one. As has just been stated, certain of the diatoms have a distinct spring and fall maximum, and there are other organisms which, because of their dependence upon the diatoms, have similar periods of maximum growth. But there are other causes at work which control the growth of individual organisms, so that their optimum periods may come at very different times of the year.

Generally speaking it is probably true that the largest amount of plankton occurs in midsummer, although Yung says that the maximum development of plankton in Lake Leman is in May or June, and that the minimum is in March and September. Zacharias states that the maximum period for Lake Plön is about August 1st. Measurements of a large number of collections from various lakes in Wisconsin indicate that the maximum of plankton occurs in these lakes in the latter part of July. The exact period of maximum development may vary from year to year, and in different lakes, because of varying local conditions. The reason for this July maximum seems to be not because any considerable number of organisms have their highest develop-

ment, but because of the fact that there is a greater variety of forms at this time than at any other time of the year. This is undoubtedly because of the peculiarly favoring conditions of temperature. It is this time of the year that seems to be especially favorable to the growth of the algæ. The 'water-bloom' may appear in June and remains sometimes until into September, but it is in July and August that it is present in the greatest quantity. This summer, on Lake Winnebago, it was most abundant during the latter half of August.

The minimum of plankton development is in the winter months, especially in January and February. At no time of the year, however, are either plant or animal forms wanting, and collections made through the ice will give a considerable variety of kinds, as well as numbers of individuals.

It will be noticed that the period of maximum plankton development corresponds to the time of highest temperature of the water, and that the period of minimum development corresponds to the time of lowest temperature, so that we can be certain that the one important controlling factor in the growth of plankton is the temperature.

Hensen and his co-laborers who worked out a very elaborate system of measuring the plankton of the sea claimed that the distribution of the plankton over wide stretches of the sea was nearly uniform. Granting this to be true, it evidently is possible by a series of collections and measurements to compare different parts of the ocean in regard to their productiveness in animal and plant life. This conclusion, that the horizontal plankton of the sea has a practically uniform distribution, has been accepted by the majority of scientists, although vigorously combated by Häckel.

Apstein has applied the same methods to the examination of lakes, and has concluded from his investigations that the plankton of lakes is uniformly distributed. It is easily seen that there is very good reason for assuming this to be the case from the actual conditions under which the plankton exists. The plankton consists of organisms that do not move voluntarily from place to place, and therefore do not change their positions. They are dependent upon heat and light for their development, so that their growth is mainly within from twenty to forty feet of the surface, so that a depth exceeding this would not mean any greater production of plankton—or in other words, the amount of plankton depends not upon depth, but upon surface.

This is a most important conclusion, if true, for it gives us an exact method by which we can compare one lake with another and determine their relative productiveness, or from a series of collections, determine the absolute annual productiveness of any body of water. Such determinations would have an important commercial value, for by them could be estimated the possibilities of fish production in a lake. The method was worked out in detail and very elaborately by Hensen. The collection was made by a conical net of bolting silk drawn vertically through the water, thus straining out the organisms of a column of water of the size of the opening of the net. Then the material was counted under the compound microscope by a very laborious process. In this way exact numerical values can be obtained not only for the plankton as a whole, but for the individual constituents. Most investigators use Hensen's methods with greater or less modifications, and they have been productive of very fruitful results. But, unfortunately—I say unfortunately, because we all like to claim exact results, and are prone to think that nature works according to certain inflexible laws—much of the laborious detail of the work is a waste of time.

The question of the uniformity of horizontal distribution has been discussed by various authors and with considerable vigor, but I think it must now be acknowledged, that while there is a certain amount of uniformity, so that, by a considerable number of collections, we can express within rather wide limits the amount of plankton at any time on a lake, uniformity in any exact sense does not exist. This lack of uniformity is largely due to a difference in the number of crustacea, although there are marked differences in the distribution of the other organisms. Surface growing plants, for instance, are moved about under the influence of the winds, and accumulate on the leeward side of a lake. If one part of a lake is deeper than another and the lake is not much disturbed by the winds, at the period of maximum growth the number of diatoms will be much greater over the deeper part. Crustacea may be in ill-defined aggregations which may be called swarms, and these swarms are not stationary in all cases, but move slowly, perhaps under the influence of extremely weak currents. Not only is there a considerable variation in collections made at different locations on a lake at the same time, but if a series of collections is made at the same place, the amount of the plankton in some collections may be twice as much as in others. An examination will show that these large variations are generally due to a difference in the numbers of some of the crustacea, showing conclusively that not only do the numbers of crustacea vary at different locations, but that these swarms are not stationary. It follows, then, that conclusions in regard to the plankton drawn from a few collections may be quite erroneous. If, however, a considerable number of collections is made, especially if they are made from widely-separated localities, the average of all these collections, allowing something of a margin for error, will give a fair idea of the amount of plankton in a lake. Of course, the larger the number of collections the less the amount of error, but anything like very exact results can not be expected. We are able, in this way, to compare the plankton of one lake with that of another, or to determine the relative amount of plankton at different times of the year on any single lake. But any estimate of the actual amount of plankton produced by a lake at any time or during the year must be acknowledged to be only an approximation. Care must be taken, too, in comparing one lake with another, that they be compared under similar conditions. The maximum of one lake may not be reached at the same period as that of another. The conditions of a deep lake are very different from those of a shallow lake, and a fair comparison can be made only by averaging collections continuing over a considerable period.

In the abyssal region, because of the lack of light, plant life is impossible, and the fauna is very meager.

It is true that the list of animals which have been found in the abyssal regions of lakes is a long one, including, as it does, protozoa, cœlenterata, worms, molluscs, bryozoa, crustacea, arachnida, insect larvæ, and some few fish, but an examination of any single lake shows that not only is the number of kinds small, but the numbers of individuals of any kind are very small. In Europe the abyssal fauna of Lake Leman has been worked up with great thoroughness. In this country very little detailed work has been done on this subject. It is not a fruitful field for research, and it is not strange that it has been neglected. In shallow lakes it is doubtful if there is any distinctive abyssal fauna. The most abundant animals in the mud of the bottom are worms, insect larvæ, gasteropod and lamellibranch molluscs, and amphipods. With these may be associated at times great

numbers of other animals, as occasionally one finds in the mud of shallow lakes large numbers of fresh-water hydra. Most if not all these animals are identical with the littoral forms, and the difference between the littoral fauna and the deep-water fauna is that in the deep water those forms which are especially dependent upon the weeds for food and protection are lacking, while we find in abundance the mud dwellers.

In the abyssal regions of deep lakes, however, we find forms which are characteristic of those regions, although they may be mingled with others that are also found in the littoral region. In the abyssal region of Green Lake, which may be considered the typical deep-water lake of Wisconsin, are found, besides some undetermined worms, a little lamellibranch, *Pisidium*, ostracods, amphipods, insect larvæ and *Mysis*. There are some protozoa in the mud, but they have not been studied. The ostracods are so numerous that their shells form a conspicuous part of the bottom deposit.

In the smaller lakes of a depth ranging from 60 to 100 feet, like the Waupaca lakes and Elkhart, a different condition of things exists. The bottom is composed of a dark mud, and is almost completely devoid of life. This has been a puzzling fact, and has been to me personally a matter of considerable disappointment because of my interest in abyssal animals. The probable explanation seems to be that these depths are rendered unfit for life by reason of the more complete stagnation of the deep water in small lakes, and because of the larger amount of organic matter which is being decomposed there. Because of the small areas of such lakes, leaves are carried from the shore all over their surfaces, and, sinking to the bottom, increase largely the amount of decaying organic matter. Partly decomposed leaves are common in the bottom collections of small lakes but rare in lakes of the size of Green Lake or Lake Geneva. This may account largely for the black color of the bottom mud. Then, in a large lake, the winds indirectly produce slow bottom currents. A prevailing wind will pile up the water at the end of a lake; this water must return in some way, and there is good reason to think that at least a part of it returns by a slow bottom current. Professor Birge tells me that his temperature observations give evidence of such a movement of the water. It follows, probably, that in the large lake there is not perfect stagnation, and hence the conditions of the bottom are more favorable for animals than in a small lake. The larger the lake, then, other conditions being equal, the greater would be the abundance of abyssal life. While there have been no accurate means of comparing the abyssal fauna of the Great Lakes with that of the smaller lakes as to quantity, such collections as have been made would indicate that it is much greater in the Great Lakes, and decreases in proportion to the degree of stagnation. If my explanation proves to be the correct one, as I feel quite certain it will, it will follow that the small deep lake will be limited in its fauna in two ways: because of its steep shores it will have a small littoral fauna and flora, and because of its stagnant deep water it will have little or no abyssal fauna.

I have thus far spoken as though all lakes had the three faunæ: littoral, limnetic, and abyssal. Generally speaking this is true, even small bodies of water showing this distinction. But occasionally the distinction is almost lost. This is true in Lake Winnebago. In spite of its great size—the lake is some twenty-eight miles long by ten or twelve broad at its greatest width—it is only about twenty-five feet deep. In its fauna there is a curious mingling of littoral and limnetic forms, littoral forms being found in the open lake, and limnetic forms even among the weeds along

shore. The explanation seems to be this: because of its slight depth the environment, even far from shore, is favorable to the growth of littoral forms. Then there is good reason for thinking that the winds have a profound effect on its waters, thus thoroughly mixing limnetic and littoral waters, and consequently causing a similar mingling of the organisms. Lake Winnebago has the characteristics, in many respects, of an enormously overgrown puddle. I do not say this, however, to show a lack of respect for this lake, for from a practical standpoint it is a most valuable possession to the state. It can support, and does support, an enormous number of fish. Few lakes can compare with it in productiveness.

All the inhabitants of fresh water are, of course, descendants of marine forms. In some cases the modifications have been very great but in others they are hardly to be distinguished from their salt-water relatives. This is true, as has already been stated, of some of the crustacea: in some of these it is difficult to make a specific distinction between the fresh-water and marine forms. Most of the environmental conditions in fresh water are so different, however, from those in the sea, that we should expect a fauna to develop itself which would differ widely from its ancestors.

It will be noticed that the most pronounced likeness to marine animals, perhaps, is found in the abyssal forms. So far as that is true, it may be explained, I think, by the uniformity of conditions existing in the depths of lakes. The temperature varies but a few degrees from one end of the year to another, and such currents as exist are slow and almost imperceptible. The abyssal fauna of a lake is subject to nearly the same conditions as that of the sea, except for the difference in the composition of the water. If, as has been supposed, the deep-water fauna of the Scandinavian lakes is descended directly from the deep-water fauna of the sea, coming from the sea into lakes having a communication with salt water, and surviving there after the lakes were cut off from the sea, and their waters had become fresh, we can see how the animals could gradually adapt themselves to their surroundings, inasmuch as the conditions of light, temperature and food supply would remain with very little change.

With the limnetic and littoral fauna, however, a very different condition exists. In our climate the temperature of the surface varies during the year from the freezing point to eighty degrees or more Fahrenheit. In shallow lakes, not only is there this variation of the surface, but the lake may be frozen to the bottom in winter, so that all forms which can not go into a resting stage of some kind are destroyed. The conditions of life are hard, and especial fitness is required in order to make survival possible. In the sea, on the other hand, the conditions even of the littoral and pelagic fauna and flora are much more uniform. It is not strange that the fresh-water animals and plants are of few kinds, and that generally they are very different from those of the sea. It is perhaps more strange that so many resemblances remain, and that the forms are so varied as they are.

To trace out the connection of the individual forms with their marine ancestors is, of course, the work of the specialists in zoology and botany. It may be noticed, however, that the present population of our lakes has come since the glacial period, in fact the lakes themselves only date from that period. So far, then, as the fauna and flora pass from one body of water directly to another, we may assume that the present animals and plants are descended from those that were pushed south by the ice, and that as the ice retreated they followed again towards the north.

Currents carry organisms from one part of a lake to another, and from one lake to

another by connecting streams: in this way animals or plants introduced at the source of a river may be carried through its whole length.

From lake to lake, too, seeds, eggs and living animals are carried by water fowl attached to their feathers or in the mud upon their feet. This is not simply from one lake to its neighbor, but many of these birds take long flights before alighting, so that the organisms are scattered over a wide stretch of territory. It is in this way, probably, that we can account for the uniformity in the fauna and flora of the lakes and the wide distribution of some of the forms. Where conditions are similar, then, we may expect likeness in the fauna and flora. As we have seen already, temperature is the great controlling factor in distribution, so that in lakes of the same latitude or the same elevation, other conditions being equal, of which the principal is depth, we may expect close similarity in fauna and flora.

We may assume, then, that the littoral fauna and flora have had their origin from neighboring bodies of water, and that as the ice retreated, the lakes were populated, partly by direct migration between contiguous bodies of water, and partly by the aid of the winds, currents and water fowls The limnetic fauna and flora is descended either from littoral forms which have gradually adapted themselves to limnetic conditions, or from pelagic forms, which, in bays where the water was less salt or brackish, have become adapted to the conditions of fresh water and have been distributed by the same agencies as the littoral forms.

Part of the abyssal fauna is descended from marine forms directly, as in the 'fauna relicta' of the Scandinavian lakes, and in the case of some of the animals in our Great Lakes. Another part of the abyssal fauna is descended from littoral forms which have gradually moved into deep water, and have been modified to suit their new environment. All the abyssal fauna of the Swiss lakes is supposed to be of this character.

What I have said thus far applies almost exclusively to lakes of the temperate zones, for it is there that lakes exist in the greatest numbers, and it is upon such lakes that most of the work of investigation has been done. But there are lakes in warmer climates, and we may expect that a thorough study of them will give us much that is new and interesting. A striking example of the extraordinary interest that may be attached to such lakes is Lake Tanganyika in Africa. Some years ago it was reported that a jelly fish was abundant in its waters. This excited the curiosity of zoologists, for the medusa is a marine form,and very rarely is found in fresh water, the most noted case being of the one found in the basin in Regent's Park, which is supposed to have been brought with plants from some tropical country. The *medusa* of Tanganyika is one of four jelly fish known to live in fresh water, and the other examples are very rare. A special expedition was organized to make an exploration of Lake Tanganyika, and although this work was very imperfectly done, the results appear to be of great interest. Along with the ordinary lacustrine fresh-water fauna there is a fauna of marine origin, but this marine fauna is not closely related to modern forms. It does, apparently, closely resemble Jurassic forms. Indeed, it is said that were some of the forms referred to a paleontologist, he would not hesitate to say that they belonged to Jurassic times. Have we here, then, a 'fauna relicta' which dates back to Jurassic times? It is too early to answer this question with any certainty, both because of our imperfect knowledge of the fauna of Lake Tanganyika, and because of our great ignorance of the geology of that part of Africa. But the mere possibility that this may be true is startling, and should incite scientists to a

thorough study of the fauna and flora of Lake Tanganyika and the other lakes of Central Africa. So far as explorations have gone this 'halolimnic' fauna as it has been named, is peculiar to Lake Tanganyika, but we may expect to find more or less of it in other lakes.

A few words in regard to the work on plankton which remains for the future investigator. It will, I think, be evident, that so far as exact and comprehensive knowledge is concerned, we have but entered a vast field. We know so little, that we can say that we are just beginning to place limits on our ignorance.

A systematic knowledge of the fauna and flora is a first and fundamental condition of comparative biological work. We need accessible manuals by which the animals and plants dealt with can be identified. Systematic work may not be the highest or the most satisfying to the investigator, but it is very necessary. The plankton student is met, at the very beginning of his work, with a difficulty that is almost a complete block to further progress; although the number of forms with which he has to deal in his plankton work may be very few, he has to have the knowledge of a specialist in each group in order to identify them. If a laboratory has a company of specialists, the material is quickly identified by passing from one to another. But if the investigator is by himself, he finds himself in a most discouraging situation. The literature of the various groups is scattered and fragmentary, and frequently is utterly useless to any one but a specialist. There is need of a manual, or rather a series of manuals, that shall so treat of the fresh water fauna and flora, that any well-trained biologist shall have no difficulty in identifying his material outside the group which he may have made his special study.

It seems to me that we have nearly reached the time when the publication of such a manual should be possible. Most of the preliminary work has been done. More, perhaps, remains to be done on the botanical side than on the side of zoology, for the exact study of the lower aquatic flora has been much neglected. I hope that the time is not far distant when we may have such a manual produced in this country, with the coöperation of our best specialists. Nothing would do more to further the study of plankton, for it would furnish the student with a tool of inestimable value.

In regard to the plankton itself, very little is really known of the abyssal fauna and its controlling conditions. I have spoken of the fouling of the water at the periods of stagnation, but our knowledge of the conditions of the water at those times is very imperfect. There should be a systematic examination, by chemical analysis of the water and its contained gases, and of the mud of the bottom, and an exact comparison should be made between the lakes with sterile bottom waters and those with a comparatively abundant fauna. In connection with this should be a study of the currents of the abyssal region. A more careful and thorough examination should be made of those lakes whose geological history indicates that they were formerly connected with the sea, and may contain a 'fauna relicta.' I may say that it is not likely that such explorations will yield any startling results. The time for that is probably past, and the lake student of the future must content himself with hard work, without the satisfaction of brilliant discoveries.

Our quantitative knowledge of plankton is only a beginning. We know something of the conditions on a few lakes, but only on a few, and we do not know what variations may be caused by the peculiarities of individual lakes. Even in the same lake the conditions may change from year to

year, and in only a few instances have observations continued through a series of years. We are all prone to generalize on the facts in our hands, but it must be acknowledged that the facts upon which we can build theories of fresh water plankton are very meager. There is need of a series of examinations of typical lakes carried on for a term of years, before we can build with certainty.

There remains the great problem, or complex of problems, of the relation of the different elements of the plankton to each other and to the fish. We see, frequently, an apparent overproduction of one of the elements. In shallow lakes—at least in many of them—there is apparently a great overproduction of vegetation. How is this explained? How is the balance of life restored? What constitutes an ideal relation between the vegetable and animal growth? When we plant a new species of fish in a lake, we, of course, disturb the existing balance of organisms, may we not, in some cases, at least, work actual damage? To what extent is this balance between animals and plants maintained in a lake that is not interfered with by man?

These and similar questions, now without answers, offer a field of almost unlimited work, and work that is worthy the best efforts of our students. For while my address, in treating of the present condition of the study of lakes, has dealt largely with isolated facts, after all it is not the facts which the student pursues as his ultimate aim, but the general laws underlying the facts. He is an unfortunate man who sees the trees, but cannot perceive the forest, who can see the stones of which the cathedral is constructed, and show how they were lifted to their places, but cannot perceive the beauty of the structure as it stands in its exquisite proportions, its massive masonry and wealth of sculptured detail only serving to express the idea of beauty and harmony in the master mind of the architect.

C. DWIGHT MARSH.

RIPON COLLEGE.

SCIENTIFIC BOOKS.

The Cambridge Natural History. By DAVID SHARP, M.A. (Cantab.), M.B. (Edinb.), F.R.S. Vol. VI. *Insects* (Part II.). London and New York, Macmillan & Co. 1899. 8°. Pp. xii+626, and 293 cuts.

The completion of that portion of the Cambridge Natural History which is devoted to insects is an event of unusual importance to entomologists; for these two volumes constitute the most useful work of its kind that has appeared since the publication of Westwood's Classification of Insects.

The most striking feature of this work is the same as that which characterized Westwood's Classification and has made it an indispensable part of every entomological library; that is, it includes the results of a careful sifting of the greater part of all entomological literature. In a word, these two volumes of the Cambridge Natural History constitute an encyclopædia of entomology, written by one who has thoroughly studied the more important contributions to all departments of entomology, and who also contributes much that is new.

An admirable feature of the work is the fact that it is well-balanced; the morphology, the taxonomy, and the œcology of insects have each received sufficiently full treatment. The student of any phase of entomology is almost sure to find someting on his subject here and to find also references to the more important literature.

The author has placed entomologists under so great obligations to him that one does not feel like saying anything but praise of his work. I cannot help feeling, however, that it would have been better if in some respects he had been less conservative. This is especially true of his treatment of the larger divisions of the class of Insecta; his conclusions on this subject are hardly an advance on what might have been written a quarter of a century ago. In fact this is the weakest part of his work. Thus, in his discussion of Brauer's classification (Vol. V., pp. 175–176), he has apparently failed to

grasp the most important point brought out by Brauer. He says (p. 175) that one of the chief characters on which Brauer bases his system is the existence or absence of wings; and later (p. 176) he says "Thus it (Brauer's classification) begins by a division of Insecta into winged and wingless; but the winged division is made to comprehend an enormous number of wingless Insects, whole subdivisions of Orders such as Mallophaga being placed in the winged series, although all are without wings." Now the fact is Brauer does not use the existence or absence of wings as a character distinguishing the two groups into which he divides the Insecta. Brauer believes that the wingless condition of the Thysanura and Collembola is due to their generalized condition; that none of their ancestors had wings. On the other hand he believes that the wingless condition of all other wingless insects is a secondary condition, that they have descended from winged ancestors. In other words that existing insects represent two distinct lines of descent; in one, the primitive wingless condition has been constantly retained; in the other are found only descendants of a common-winged ancestor. This distinction is clearly indicated by the names he proposed for the two groups, Apterygogenea and Pterygogenea. The fact that many of the Pterygogenea have lost their wings does not militate in the least against this distinction. The only indication that our author has understood Brauer's position is a statement that "This first division is entirely theoretical." But if we give him credit for understanding Brauer we must blame him for stating the case in a very misleading manner.

As a rule, however, the work is written in a clear, simple style. The illustrations are abundant and are excellent; and the pages present an attractive appearance. It is a work that no entomologist can afford to be without.

J. H. Comstock.

Traité de Zoologie Concrète. By Yves Delage and Edgard Hérouard. Tome 11, 1re Partie, Mésozoaires, Spongiares. Paris, Schleicher Frères. 244 pages 15 colored plates and 274 text figures. 1899.

In the most recent volume of their 'Concrète Zoology' Delage and Hérouard present, from the teacher's standpoint, one of the most difficult branches of Invertebrate Zoology, and only praise is due them for the excellent manner in which the subjects are treated.

The group including the two families Dicyemidæ and Orthonectidæ, to which Van Beneden gave the name Mesozoa as indicative of their supposed intermediate position between the Metazoa and the Protozoa is considerably enlarged by the addition of a number of forms which show less evidence of degeneration than do Van Beneden's original types. The classification, however, is only provisional, for in most cases the life history is not known and it is recognized that future investigations may show the forms in question to be only larval stages of other animals. With this in mind the authors make four classes of the Mesozoa as follows, the name of each class indicating the nature of the sub-ectodermal structures: (1) Mesocoelia.—Forms having a digestive cavity with no other cellular boundary than the ectoderm (Frenzel's *Salinella salve*). (2) Mesenchymia.—Forms having a parenchymatous tissue within the ectoderm and without a digestive cavity (*Trichoplax* and *Treptoplax* (Monticelli)). (3) Mesogonia.—Forms without digestive cavity and with one or several cells beneath the ectoderm which are destined for sexual reproduction (Dicyemidæ and Orthonectidæ). (4) Mesogastria.—Forms having a digestive tract like the archenteron of a gastrula, the walls being separated from the ectoderm by a coelomic cavity in which there is no intermediate tissue (*Pemmatodiscus*, a parasite on *Rhizostoma pulmo* (Monticelli)). In addition to these classes, Haeckel's Physemaria, the 'urn' forms in the cavities of the Sipunculidæ, and the curious form described by Caullery and Mesnil under the name *Siedleckia nematoides*, are included as appendices.

In the second part of the volume the authors put into their subject an intimate knowledge gained only by personal investigation and continued research upon the structure and the development of the Sponges. The result is a clear and concise presentation of the numerous complicated Sponge-structures. The canals, inhalent and exhalent, with their many con-

fusing branches and chambers, are admirably portrayed and their mode of origin from the simple condition of an hypothetical rhagon-type is clearly shown. The spicules have received especial attention and the confusing nomenclature is presented in a table where ninety-eight different types of spicules are described and named in accordance with the views of Sollas, Lendenfeld, Stewart, and Schultze. With only eight exceptions a figure of the spicule accompanies each description and with this table, an average student for the first time, can classify Sponges while the admirable schematic figures of the organisms will help him to understand their structure.

The Sponges are divided as usual into two branches, CALCARIA and INCALCARIA. The former is subdivided into two orders, Homocœlida and Heterocoelida (both adapted from Poléjaef); the latter is further divided into two sub-classes, Triaxoniæ (F. E. Schultze) and Demospongiæ (Sollas). The first sub-class includes two orders, Hexactinellida (Zittel, Lendenfeld) and Hexaceratida (adapted from Lendenfeld); the second sub-class includes three orders, Tetractinellida (Marshall) Monaxonida (Ridley and Dendy) and Monoceratida (Lendenfeld). The further divisions are made in accordance with the nature and disposal of the spicules. An improvement in the editing of the volume, although of minor importance, is noted in the presence of the name of the family to which the various genera belong and this cannot fail to help the student.

As with the previous volumes disputed questions are clearly stated and the arguments on both sides are fairly presented, the authors in most cases taking a decided stand upon one side or the other. If a critic wished to hunt for defects in the work he might be successful in the section which treats of the physiology of nutrition; this portion of the volume is not complete enough.

In connection with the taxonomic position of the Sponges, the authors maintain with Hatschek, Perrier and Parker and Haswell that they represent a phylum entirely distinct from all other types. In their opinion one character is sufficient to justify separation from the Coelenterata and from all other groups. This feature is the fact first made out by Delage, that the germ layer which corresponds to the ectoderm of other Metazoa, passes during gastrulation to the interior, where it forms the choanocytes in the walls of the ciliated chambers, while the endoderm layer becomes superficial and forms the definitive external covering. They also state that ontogeny throws no light at all upon the relationships of the group.

GARY N. CALKINS.

DEPARTMENT OF ZOOLOGY,
COLUMBIA UNIVERSITY.

A Memoir on the Palæzoic Reticulate Sponges constituting the family Dictyospongidæ. By JAMES HALL in collaboration with JOHN M. CLARKE. (Memoir II, State Museum New York, 1898 [October, 1899], pp. 350, plates I–LXX, royal 4to. A portion of this work also appeared simultaneously with the same title, in the Fifteenth Annual Report of the State Geologist for the year 1895, Vol. II, pp. 743–984, plates 1–47.)

This volume is practically a continuation of the 'Paleontology of New York,' and had its inception in 1884. In 1890, but 42 species of *Dictyospongidæ* were known, and there are now described and figured all the paleozoic representatives of the living 'glass sponges,' of which there are 128 species. "This wonderful increase is not especially a matter for congratulation, save that it serves to show the amazing diversity of these silicious sponges in late Devonian and early Carboniferous faunas." All but 6 species are American. When the fact is noted that most collections contain but few specimens of these sponges, it is a surprise to learn that 70 species alone are found in the Upper Devonic of New York and Pennsylvania. It is mainly in New York that the great fossil 'sponge plantations' occur, and these have been and continue to be worked by Mr. Edwin B. Hall of Wellsville, to whom belongs the credit of having by far the largest collection of these extinct forms. From some of the New York localities several hundred specimens of a kind have been taken, but usually a single species is found in each or this may be even restricted to one colony.

Conrad (1842), was the first to record these

fossils, regarding his *Hydnoceras* as a cephalopod. In the same year Vanuxem described another form, *Uphantænia*, as a plant, and this was the current interpretation for all the *Dictyospongidæ* until 1881, when Whitfield, from Lower Carbonic material, determined that they were the remains of sponges. Nearly all these fossils are found in sandstone, while the living *Euplectellas* are commonly anchored on muddy bottoms.

The present monograph begins with 'General Observations on the Sponges.' These are followed by sections on the affinities, structure of the skeleton, preservation, and occurrence, of the *Dictyospongidæ*. A detailed review of the bibliography, in which there are 42 entries, is next given, and then come a classification and the descriptions of genera and species. The family *Dictyospongidæ* is here divided into seven sub-families, all new. These are: *Dictyospongiinæ*, *Thysanodictyinæ*, *Calathospongiinæ*, *Physospongiinæ*, *Hyphantæniiæ*, *Hallodictyinæ*, and *Aglithodictyinæ*. Of new genera there are *Dictyospongia*, *Hydriodictya*, *Prismodictya*, *Gonglospongia*, *Botryodictya*, *Tylodictya*, *Helicodictya*, *Rhabdosispongia*, *Ceratodictya*, *Lebedictya*, *Thysanodictya*, *Arystidictya*, *Aclæodictya* *Griphodictya*, *Calathospongia*, *Clepsydrospongia*, *Roemerispongia*, *Hallodictya* and *Aglithodictya*. *Mastodictya* is another new genus, but is undefined. *Sphærodictya* is proposed to replace in part *Teganium* Rauff, which seems to include heterogeneous material. *Cyathophycus* is considered objectionable, because the name indicates a plant. On this ground Dawson changed it to *Cyathospongia*, a name used earlier by Hall. In this volume, the latter term is replaced by *Cyathodictya*. It is a question whether anything is gained by these changes (*Cyathophycus* to *Cyathodictya*, and *Uphantænia* to *Hyphantænia*).

Hydnoceras Conrad was proposed for 'an extravagant type of orthoceran cephaloped.' This, however, never came into use and is here revived 'not because it was founded on a misconception, but because it perpetuates one' (*sic*). On the other hand *Dictyophyton* was introduced by Hall in 1863, 'at the request of Mr. Conrad * * * to replace the term *Hydnoceras*.' The genotype is *D. newberryi*, which was also accepted for *Thamnodictya* in 1884. Under the rules of nomenclature such changes are not usually permissible, but since *Dictyophyton* 'tends to perpetuate the old and erroneous conception of the algous nature of these fossils' the name may be allowed.

The paleontology of New York serves as the highest expression of the work on American invertebrates, not only from a scientific standpoint, but also in artistic appearance. This volume on the sponges continues the previous standard, in spite of the fact that the preservation of the extinct glass sponges does not permit of much detailed elaboration. From an artistic standpoint, the present monograph is equalled by no other, not even by the elaborate 'Systeme Silurien du Centre de la Boheme' of Barrande. Professor Hall long ago recognized the accurate and artistic draughtsmanship of Mr. George B. Simpson and the ability of Mr. Philip Ast in lithographic work. Few can appreciate the skill and patience of the latter in overcoming technical difficulties. For 50 years New York has nobly supported her workers in pure science, and paleontologists look to that Commonwealth and to Dr. Clarke for a continuance of the splendid series of volumes on the paleontology of the State.

Charles Schuchert.

BOOKS RECEIVED.

The International Geography, by seventy authors. Edited by Hugh Robert Mill. New York, D. Appleton & Co. 1900. Pp. xx + 1088. $3.50.

Jenaer Glas und seine Verwendung in Wissenschaft und Technik. H. Hovestadt. Jena, Fischer. 1900. Pp. xii + 429. 9 Mark.

The Criminal. August Drähms, with an introduction by Cesare Lombroso. New York and London. The Macmillan Company. 1900. Pp. xiv + 402. $2.00.

Municipal Government. Bird S. Coler. New York, D. Appleton & Co. 1900. Pp. ix + 200.

Man and his Ancestor. Charles Morris. New York and London. The Macmillan Co. Pp. vi + 238. $1.25.

SCIENTIFIC JOURNALS AND ARTICLES.

The January number (Vol. I., No. 1) of the *Transactions* of the American Mathematical Society contains the following articles: 'Conics and cubics connected with a plane cubic by

certain covariant relations,' by H. S. White; 'Formentheoretische Entwickelung der in Herrn White's Abhandlung über Curven dritter Ordnung enthaltenen Sätze,' by P. Gordan; 'Sur la définition générale des fonctions analytiques, d'après Cauchy,' by E. Goursat; 'On a class of particular solutions of the problem of four bodies,' by F. R. Moulton; 'Definition of the Abelian, the two hypoabelian, and related linear groups as quotient-groups of the groups of isomorphisms of certain elementary groups,' by L. E. Dickson; 'Note on the unilateral surface of Moebius,' by H. Maschke; 'On regular singular points of linear differential equations of the second order whose coefficients are not necessarily analytic,' by M. Bôcher; 'The elliptic sigma-functions considered as a special case of the hyper-elliptic sigma-functions,' by O. Bolza; 'On the groups which are the direct products of two subgroups,' by G. A Miller; 'On certain crinkly curves,' by E. H. Moore; 'A new definition of the general Abelian linear group,' by L. E. Dickson.

THE February number of the *Bulletin* of the American Mathematical Society contains the following articles: Report of the annual meeting of the Society, by the Secretary; a report of the December meeting of the Chicago Section, by Professor T. F. Holgate; 'On cyclical quartic surfaces in spaces of n dimensions,' by Dr. Virgil Snyder; 'On the singular transformations of groups generated by infinitesimal transformations,' by Professor Henry Taber; 'Proof of the existence of the Galois field of order p^r for every integer r and prime number p,' by Professor L. E. Dickson; a review of Méray's Infinitesimal analysis, by Professor E. Lovett; 'Notes'; and 'New Publications.'

THE contents of the March number of the *American Journal of Science* are as follows:

'Hot Water and Soft Glass in their Thermodynamic Relations,' by C. Barus.

'Conrad's Types of Syrian Fossils,' by C. E. Beecher.

'Electrical Thermostat,' by W. Duane and C. A. Lory.

'Toxic Action of a Series of Acids and of their Sodium Salts on Lupinous Albus,' by R. H. True.

'Explorations of the *Albatross* in the Pacific,' by A. Agassiz.

'Ægirite Granite from Miask, Ural Mountains,' by L. V. Pirsson.

'Illinois Gulch Meteorite,' by H. L. Preston.

'Silurian-Devonian boundary in North America,' by H. S. Williams.

SOCIETIES AND ACADEMIES.

THE ANNUAL MEETING OF THE NEW YORK ACADEMY OF SCIENCES, FEBRUARY 26, 1900.

PROFESSOR HENRY F. OSBORN, President of the Academy, opened the meeting with a brief address in which he spoke particularly of the needs of the Academy in reference to a permanent home, and a larger publication fund; of the work of the sections of the Academy, particularly of that of the Section of Anthropology and Psychology, in association with the recently organized Ethnological Society; and of the Section of Astronomy and Physics, which has lately added Chemistry to its field of operations. Professor Osborn paid brief tribute to certain of our distinguished Honorary members who have died during the year, particularly to Professor Bunsen, Dr. Geinitz, Sir William Dawson, and Sir William Flower.

The Recording Secretary reported a total of 333 resident members, and analyzed the 82 papers given before the Academy during the last year, as to their subjects, showing that the largest attention has been given to anthropology, astronomy, geology, paleontology, petrography, physics, and zoology. The Recording Secretary also reported that the annual reception and exhibition which was held in April, in the American Museum of Natural History, was, like its predecessors, extremely successful. For the first time since the reception has been held in the American Museum it was possible to have an unoccupied room, whereby there was no confusion between the Academy and Museum exhibits. The same plan will be followed during the coming year. The Academy feels that it owes a great deal to the President and Trustees of the American Museum of Natural History, for their kindness and courtesy in allowing the Annual Reception to be held in the Museum, under such favorable auspices, and at such a moderate expense to the Academy.

The Council feels that the success and increased interest evident in the meetings since

the removal of the meeting place to its present building (12 West 31st Street) is a very pleasing feature in the Academy's work. Almost without exception the meetings of the various sections have been individually and as a whole largely increased in attendance during the last year and a-half.

"The work of the Recording Secretary's office has been systematized and in many ways improved during the last year, so that the necessary and frequent details are managed more efficiently and with less expenditure of energy and time."

The Treasurer reported cash on hand $2239.11, with total assets of $15,059.11.

The Librarian reported that the library consisted in round numbers of about 9000 volumes, of which hardly 5 per cent. are in separate title. During the year the library has been well housed in Schermerhorn Hall, Columbia University, the card catalogue and shelf list have been rearranged and the library in every way has been made more workable and serviceable.

The Editor reported that Vol. XII. of the *Annals*, now in press, of which one part has already appeared, contains 14 papers, and about 600 pages. He also reported the appearance of Part I., Vol. II. of the *Memoirs*, devoted to 'The So-Called Devonian Lamprey, *Palæospondylus gunni*,' by Dr. Bashford Dean. The edition of the *Annals* has been increased from 1000 to 1250, and the exchange list has been extensively revised.

The following Honorary and Corresponding Members were then elected, and nine resident members were, 'because of their scientific attainments and services,' made Fellows:

Honorary Members.—Julius Hann, Ph.D., University of Graz; Edward Charles Pickering, LL.D., Harvard University; Jules-Henri Poincaré, F.R.S., Faculty of Sciences, Paris; Henry Augustus Rowland, LL.D., Johns Hopkins University; Edward Burnett Tylor, D.C.L., LL.D., F.R.S., University of Oxford.

Corresponding Members.—Albert De Lapparent, École Libre de Hautes Études, Paris; William Henry Holmes, United States National Museum, Washington, D. C.; Kakichi Mitsukuri, Ph.D., Imperial University of Tokyo, Japan; George Howard Parker, Ph.D., Harvard University, Charles Richard Van Hise, Ph.D., University of Wisconsin; Sho Watasé, Ph.D., Imperial University of Tokyo, Japan.

Fellows.—Dr. W. S. Day, Secretary Section of Astronomy, Physics and Chemistry; James Douglas, President American Institute of Mining Engineers; Jonathan Dwight, Jr., Ornithologist; Dr. Marshall A. Howe, Curator Columbia University Herbarium; Professor Charles H. Judd, Professor of Psychology, New York University; Dr. E. G. Love, Entomologist; Alfred W. Trotter, Mining Expert and Civil Engineer; Dr. Henry S. Washington, Petrographer; Dr. Theodore G. White, Paleontologist.

The list of officers given below was then elected by ballot:

President: Robert S. Woodward.
First Vice-President: Charles A. Doremus.
Second Vice-President: Franz Boas.
Corresponding Secretary: William Stratford.
Recording Secretary: Richard E. Dodge.
Treasurer: Charles F. Cox.
Librarian: Livingston Farrand.
Councillors: Daniel W. Hering, Frederic S. Lee, Harold Jacoby, M. I. Pupin, Edw. L. Thorndike, L M. Underwood.
Curators: Harrison G. Dyar, Alexis A. Julien, George F. Kunz, Louis H. Laudy, E. G. Love.
Finance Committee: Henry Dudley, John H. Hinton, Cornelius Van Brunt.

After a brief address by the President-Elect, the retiring President delivered his presidential address, entitled 'The Geological and Faunal Relations of Europe during the Tertiary period, and the Theory of the Successive Invasions of the Ethiopian Fauna,' which will be printed in this Journal.

Richard E. Dodge,
Recording Secretary.

American Mathematical Society.

The first number has recently appeared of the *Transactions of the American Mathematical Society*, published quarterly by the Society with the coöperation of Harvard University, Yale University, Princeton University, Columbia University, Haverford College, Northwestern University, Cornell University, The University of California, Bryn Mawr College, The University of Chicago; edited by Eliakim Hastings

Moore, Ernest William Brown, Thomas Scott Fiske; New York, The Macmillan Company. The *Transactions*, which is devoted to the publication of important researches presented at the meetings of the Society, is quarto in size, and the annual volume will contain not less than five hundred pages. The contents of the first number are noted elsewhere.

The Annual Register of the Society has recently been issued, and contains a directory list of publications, list of officers and members, Consitution and By-Laws, and annual reports. Copies may be obtained from the Secretary.

A regular meeting of the Society was held at Columbia University on Saturday, February 24, 1900. As usual, the programme occupied a morning and an afternoon session. President R. S. Woodward occupied the chair. A part of the afternoon was devoted to a joint meeting with American Physical Society, at which a paper on Latitude Variation was presented by Professor J. K. Rees.

A revision of the By-Laws, affecting mainly their arrangement, was adopted. Notice was also given of a proposed amendment of the Constitution enlarging the Council by making the ex-presidents permanent members and increasing the number of elected members by three. The following persons were elected to membership in the Society: Professor Anne L. Bosworth, Rhode Island College, Kingston, R. I.; Mr. H. L. Coar, University of Illinois, Urbana, Ill.; Dr. F. R. Moulton, University of Chicago, Chicago, Ill.; Mr. F. G. Radelfinger, Hydrographic Office, Washington, D. C. Two applications for membership were received.

The following papers were presented at this meeting:

(1) DR. ALEXANDER MACFARLANE: 'On the nabla of quaternions.'

(2) DR. M. B. PORTER: 'On the number of roots of $F(\alpha, \beta, \gamma, x)$ between zero and 1.'

(3) MR. H. W. KUHN: 'List of the imprimitive groups of degree fifteen.'

(4) DR. G. A. MILLER: 'On the groups of isomorphisms.'

(5) DR. J. I. HUCHINSON: 'The Hessian of the cubic surface, II.'

(6) PROFESSOR MAXIME BÔCHER: 'Some theorems concerning linear differential equations of the second order.'

(7) PROFESSOR J. K. REES: 'Results of seven years' observations for variation of latitude and the constant of aberration, made at the Columbia University Observatory.'

(8) DR. G. W. HILL: 'On the extension of Delaunay's method in the lunar theory to the general problem of planetary motion.'

(9) PROFESSOR E. B. VAN VLECK: 'On linear criteria for determining the circle of convergence of a power series.'

(10) PROFESSOR F. MORLEY: 'The metrical geometry of the plane n-line.'

(11) PROFESSOR L. E. DICKSON: 'Two triply infinite systems of non-isomorphic simple groups of equal order.'

(12) PROFESSOR L. E. DICKSON: 'Isomorphism between certain systems of simple linear groups.'

(13) DR. L. W. REID: 'A table of class numbers for cubic number bodies with the method of their calculation.'

After the meeting many of the members dined and passed a pleasant evening together. The next meeting of the Society will be held on Saturday, April 28th. The Chicago Section meets at Northwestern University, Evanston, Ill., on Saturday, April 14th. The summer meeting of the Society will be held in New York, in June, in affiliation with the meeting of the American Association for the Advancement of Science.

F. N. COLE,
Secretary.

COLUMBIA UNIVERSITY.

THE TEXAS ACADEMY OF SCIENCE.

THE regular monthly meeting of the Texas Academy of Science was held in the Chemical lecture room of the University of Texas on Friday evening, January 12th, President Simonds in the chair.

The first paper on the program, entitled, 'The Red Sandstone of the Diablo Mountain, Texas,' was by Mr. E. T. Dumble, of Houston, formerly State Geologist. The sandstone here discussed is found north of Allamore station on the Texas and Pacific Railway, and is the rock enclosing the copper vein, a part of which has been known for some years as the Hazel mine. Professor Streeruwitz in one of his reports on the region states that this formation is possibly Devonian, basing his statement, as Mr. Dumble

understands it, entirely on the petrographic character of the rock, as it contains no fossils, and on its relation to the Carboniferous deposits in the hills north of the mine. Mr. Dumble has studied this sandstone, if it really be such, with considerable care, and finds it to occupy a position much lower in the geological scale than had been previously thought—that it is, in fact, below the Texan Group of Comstock—that is, at the very base of the sedimentary series. He does not believe that it is a part of an immense mass or boss of igneous material.

Mr. A. C. McLaughlin, for several years past connected with the Geological Survey of Maryland, gave an account of the work as conducted by that organization in the western part of the State.

Professor T. U. Taylor, of the Department of Engineering, read and commented upon a communication received from Professor W. H. Echols, of the University of Virginia, on the 'Measure of Earthwork,' in which the prismatic formulæ were employed.

Dr. S. E. Mezes followed with a paper on 'Monogamous Marriage,' in which he gave an account of this institution and of the rules and customs by which it has been maintained. That this institution is adapted to the highest civilization was shown in the fact that by it, and it alone, could be made a home, and that the home-training of children produced the highest and best results socially. The paper was both thoughtful and candid and received the hearty approval of all who heard it.

F. W. S.

University of Texas.

DISCUSSION AND CORRESPONDENCE.

MARGINAL TABS FOR LOGARITHM TABLES.

To the Editor of Science: Will you permit me, through the columns of Science, to bring to the attention of users of my 'Computation Rules and Logarithms,' a set of 'Marginal Tabs' for use in that book. The tabs are arranged for the five-place tables of logarithms of numbers and of the trigonometrical functions. They not only materially lessen the time required to find any logarithm or antilog in the use of the tables to five places, but they render the table even more speedy than the ordinary four-place table for obtaining the logarithms or antilogs to four places, while also much lessening fatigue and liability to mistake, no interpolation being required. The printed tabs, with directions for their application and use, form a leaflet which will be mailed by the author on receipt of twenty-five cents. Copies of the *errata* of the first (very thick paper) impression of the Tables, but which have been corrected in later impressions, will be mailed to holders of that edition on receipt of a stamped and addressed envelope.

S. W. Holman.

18 Elm Street, Brookline, Mass.,
February 24, 1900.

NOTES ON PHYSICS.

In the London *Electrician* is a report of some recent experiments of Professor S. Lussana on the variation of resistance under high pressures, up to 1000 atmospheres. He found the resistance to decrease with increase of pressure, and obtained the following coefficients per atmosphere.

Lead	194×10^{-7}		
Iron	38	Argentana	9.7×10^{-7}
Silver	32	Nickelina	7.4
Copper	31	Constantea	7.9
Platinum	24	Manganin	5.6
Nickel	19	Brass	4.3

The curves of decrease of resistance were slightly concave toward the axis of pressure, showing a tendency toward a minimum.

The resistance did not return to its normal immediately on removal of the pressure. In the case of platinum which had been under a pressure of 500 atmospheres for one hour, the resistance, on removal of the pressure, increased rapidly for ten minutes, and then quite slowly, taking about one hour to return to approximately its normal. Held under the same pressure for 24 hours, the curve showing its return with time to normal resistance is very interesting, rising in about 50 minutes to normal, going above, returning again to normal in about 7½ hours, falling below, and again becoming approximately normal in about 14 hours, thus showing a series of waves of decreasing magnitude and increasing length.

In the same journal of January 26th is an abstract of a Royal Society paper by C. E. S. Phillips, on 'Diselectrification produced by Magnetism.' Foil was cemented on the inner and outer surfaces of a glass tube, and powerful magnet poles were inserted through air-tight flanges. When the tube was exhausted below .2″ of mercury, and the inner coating was connected to the positive side of an electrical machine, an electroscope attached to the inner coating showed a rapid discharge on opening or closing the circuit of the magnet. With higher pressures or when the inner coating was negative there was no effect. When the electroscope was attached to the iron of the magnet poles, it indicated that the charge was transferred to these.

F. C. C.

ZOOLOGICAL NOTES.

BIRD MIGRATION.

IN a recent issue of the *Proceedings of the California Academy of Sciences*, Leverett M. Loomis gives a fourth part of his 'California Water Birds,' including his deductions from a careful study of their migrations. He concludes that the Shearwaters off Monterey find their position and shape their course by landmarks, and that birds possess no mysterious superhuman faculty for determining direction, or else these same Shearwaters would not have been bewildered in the fog. He also considers that the young are guided from the place of their birth to their winter abode through the experience of the older birds, and that the mere presence of young alone in a locality does not prove that they are migrating independently of the adults, but that older birds have either continued their flight or are migrating farther off. Mr. Loomis sums up by saying that bird migration is a habit evolved by education and inheritance which owe their origin and perpetuation to winter, with its failure of food.

THE STEREORNITHES AGAIN.

IN the December number of *Communicaciones del Museo Nacional de Buenos Aires*, Senor Mercerat discusses the zoological position of the gigantic birds from the Santa Cruz beds of Patagonia, and considers them as an independent 'gens' of the suborder Ciconiiformes of Fürbringer. While this is all right, Senor Mercerat unfortunately adds that the Stereornithes are a degenerate group of birds, but that they have not progressed so far on their downward course as the so-called Ratitae, and that they present numerous characters similar to those of the Carinatae, combined with others peculiar to the Ratitae. What these ratite characters are, aside from the feeble development of the wings, no one has yet satisfactorily explained, and Mr. C. W. Andrews, in his recent memoir on *Phororhacos*, shows very clearly that the Stereornithes have no kinship with the Ostriches. Size and flightlessness are not morphological characters and have no bearing whatever on the systematic position of the bird. It was a favorite remark of the late Professor Cope that an animal a mile long and an inch wide might belong to the same genus as one a mile wide and an inch long, and this might be paraphrased by saying that a bird with wings twenty feet across might be the nearest relative of a bird with no wings at all.

F. A. L.

THE ASSAY COMMISSION.

THE Assay Commission, which is appointed annually by the President to test the weight and fineness of the coinage of the mints in operation during the preceding year, met at the Philadelphia mint on February 14th. The men whom President McKinley designated to serve for the year 1900 were: Senator John P. Jones, of Nevada; Representative E. J. Hill, of Connecticut; Dr. H. S. Pritchett, Superintendent of the Coast and Geodetic Survey; Professor S. A. Lattimore, of the University of Rochester; Professor H. H. Nicholson, of the University of Nebraska; Dr. J. A. Mathews, of Columbia University; Dr. Cabell Whitehead, Assayer of the Bureau of the Mint; Dr. Marcus Benjamin, of the Smithsonian Institution; Hon. John H. Perry, of Connecticut; Calvin Cobb of Boise, Idaho; Thomas B. Miller of Helena, Montana; Edward Harden, of New York City; E. H. Rich, of Fort Dodge, Iowa, and Francis Beidler, of Chicago. The Commission also includes three ex-officio members, viz., the judge of the District Court of the

Eastern District of Pennsylvania, Judge McPherson; the Comptroller of the Currency, Hon. Charles G. Dawes, and the Assayer of the New York Assay Office, Dr. Herbert G. Torrey.

The work of the Commission consists in counting, assaying and weighing samples representing the coinage of the mints at Philadelphia, New Orleans and San Francisco. For this trial one one-thousandth of all gold coins and one two-thousandth of all silver coins made during the year are sent to the Philadelphia mint under seal and kept for the meeting of the Commission. The coinage during the past year was larger than ever before and hence the labor of the Commission was increased. The trial pieces numbered over forty-one thousand. The work of the Commission was divided among three committees; the chairman of which, as announced by Mr. George C. Roberts, Director of the Mint were: Counting, Hon. E. J. Hill; Assaying, Dr. H. S. Pritchett; Weighing, Dr. J. A. Mathews. The investigations of these committees serve as a check upon the accuracy of the work at the several mints, as well as upon the Bureau of the Mint in Washington.

SCIENTIFIC NOTES AND NEWS.

Since making appropriations in March, 1899, of $500 to Professor Charles L. Doolittle, and of $300 to Mr. Henry M. Parkhurst, from the Benjamin Apthorp Gould Fund, a considerable additional amount of income has accrued, for the distribution of which the Directors are prepared immediately to arrange. Applications for appropriations may be made by letter to Mr. Lewis Boss, Albany, Dr. Seth C. Chandler, Cambridge, or to Professor Asaph Hall, Cambridge.

An item in the Urgency Deficiency Bill, which has now passed both Houses of Congress, makes an appropriation of $7500, for continuing the biological and economic investigations on the lobster and clam. The investigations deal with the practical aspects of the subject, and it is purposed to carry on the work in all States having clam and lobster fisheries, from Maine to Delaware inclusive.

A committee, consisting of Mr. James E. Scripps, Mr. George W. Bates, of Detroit, and Professor Francis W. Kelsey, of the University of Michigan, was appointed at the annual meeting of the Detroit branch of the Archæological Institute of America, and was instructed to name a general committee to prepare a memorial to be submitted to the next State Legislature on the subject of an archæological survey of Michigan. The present knowledge of Michigan archæology is meagre, and is given in 'The Data of Michigan Archæology,' by Harlan I. Smith, published in the *American Antiquarian* for May, 1896.

The University of Edinburgh will confer the degree of LL.D., on Eleanor A. Ormerod, the entomologist. The University of Edinburgh has not hitherto conferred an honorary degree on a woman.

Wabash College, situated at Crawfordsville, Indiana, has conferred an honorary degree of Ph.D. on Professor Asa H. Morton, professor of romance languages, at Williams College. If Professor Morton has not been consulted in regard to this doubtful honor, he may see fit to decline it.

Dr. Charles W. Dabney, president of the University of Tennessee, has received notice from the French Government of his appointment as a member of the Committee on International Awards at the Paris Exposition.

Professor R. W. Wood, of the University of Wisconsin, who is now in England, will return to Madison at the end of March after visiting Berlin and Paris.

Mr. William C. Whitney has presented two fine bisons to the New York Zoological Park. One of them is from the herd of the late Austin Corbin at Blue Mountain Park, N. H. The other is from Mr. Whitney's herd at Lennox, Mass.

Professor E. J. McWeeny, professor of pathology and bacteriology at the Catholic University of Dublin, has been appointed to the newly created post of bacteriologist to the Irish Local Government Board.

The trustees of the Philadelphia Academy of Surgery announce that the Samuel D. Gross prize was not awarded on January 1st, as no suitable essay was presented. It will be awarded on October 1, 1901. The prize, the

value of which is $1,000, is awarded to an American citizen for an essay not exceeding 150 octavo pages, containing original investigations on surgical pathology or surgical practice.

THE Senate Sub-Committee, responsible for the bill interfering with vivisection in the District of Columbia, gave a hearing on February 21st. Among those who opposed the bill were Professor H. P. Bowditch, Surgeon General Sternberg, Professor W. W. Keen, Professor W. H. Welch, Professor William Osler, Professor Howard A. Kelly, Professor H. H. Hare, Dr. Mary P. Jacobi, and Bishop Lawrence.

WE regret to record the death of M. Émile Blanchard, member of the section of anatomy and zoology of the Paris Academy of Sciences.

WE must also announce the death at the age of 76 years of Dr. Hermann Schaeffer, honorary professor of mathematics at Jena.

IT is perhaps not generally known that the late Professor D. E. Hughes, the physicist and inventor, whose death we were recently compelled to record spent about twenty years in the United States. He was educated at Bardstown, Ky., where he afterwards taught 'natural philosophy.'

THE first part of Römer und Schaudinn's *Fauna Arctica* has appeared. It is a beautiful quarto, and contains papers by Schulze, Thiele, von Linstow and Ludwig, on the Hexactinellidæ Proneomenia, the Nematodes and Holothurians, respectively.

DURING the present month lectures on metallurgy are being given at the American Museum of Natural History under the auspices of Columbia University. The lectures, which are on Saturday evenings, are as follows:

March 3. 'The Constitution of Steel as revealed by the Microscope,' by Professor Henry M. Howe, of Columbia University.

March 10. 'The Constitution of Metallic Alloys in the Light of Modern Research,' by Mr. Albert Sauveur, Lecturer on Metallurgy, Harvard University.

March 17. 'Toledo Blades: Rationale of the Procedure in Manufacturing them and other Steel Objects explained by the Microscope,' by Henry Souther, Consulting Engineer, of Hartford, Conn.

March 24. 'Lead Smelting in the United States,' by Professor H. O. Hofman, of the Massachusetts Institute of Technology, Boston, Mass.

March 31. 'Aluminium,' by Professor J. W. Richards, of the Lehigh University, South Bethlehem, Pa.

THE thirteenth Lecture Course on science and travel at the Field Columbian Museum will be given during March and April on Saturday afternoons at 3 o'clock. The subjects and dates of lectures are as follows:

March 3. 'The Age of Steel,' by Mr. H. W. Nichols, Assistant Curator, Department of Geology, Field Columbian Museum.

March 10. 'Conditions of Life in Inland Lakes,' by Dr. E. A. Birge, Professor of Zoology, University of Wisconsin.

March 17. 'Gigantic Fossil Reptiles from the Jurassic of Wyoming,' by Mr. E. S. Riggs, Assistant Curator of Paleontology, Field Columbian Museum.

March 24. 'Primitive American Art with Illustrations Drawn chiefly from Studies in Aboriginal Games,' by Mr. Stewart Culin, Director of the Museum of Science and Art, University of Pennsylvania.

March 31. 'Archæological Discoveries on the North Pacific Coast of America, by Mr. Harlan I. Smith, American Museum of Natural History, New York.

April 7. 'Soyaluna, a Hopi Winter Solstice Ceremony,' Stanley McCormick Expedition, by Rev. H. R. Voth, Missionary to the Hopi Indians.

April 14. 'The 'Struggle for Existence' as a Factor in Animal Development,' by Dr. D. J. Rettger, Indiana State Normal School, Terre Haute, Indiana.

April 21. 'The Yellowstone National Park,' by Professor J. P. Iddings, University of Chicago.

April 28. 'Indian Tribes of the Great Plains,' by Mr. James Mooney, Bureau of Ethnology, Washington, D. C.

A TELEGRAM has been received at the Harvard College Observatory from Professor J. E. Keeler at Lick Observatory stating that the following elements and ephemeris of Comet '*a*' were computed by Professor Perrine.

Time of passing perihelion	$= T =$	1900 April 29.08
Perihelion minus node	$= \omega =$	24° 37′
Longitude of node	$= \Omega =$	40° 25′
Inclination	$= i =$	146° 25′
Perihelion distance	$= q =$	1.3289

Ephemeris.

1900 Feb. 26	R.A.	2^h	09^m	52^s	Dec.	+1°	43′	Lat. 0.85
Apr. 2	"	2	05	36	"	2	56	
Mar. 6	"	2	01	52	"	4	07	
Mar. 10	"	1	58	32	"	+5	15	Lat. 0.82

Computed from observations on February 3d and 8th.

UNIVERSITY AND EDUCATIONAL NEWS.

Mr. A. W. Grabau has been appointed instructor in geology in the Rensselaer Polytechnic Institute, Troy, N. Y.

Oberlin College receives $75,000 by the will of the late Mrs. Caroline E. Haskell of Michigan City, Indiana, and $40,000 by the will of the late William Osborne of Pittsburg.

By provision of the will of the late Dr. John Stanford Sayre, U. S. N., retired, Princeton University will receive $40,000, part of which is for the endowment of fellowships in applied chemistry and in applied electricity.

Under the will of the late Mr. Joseph Kaye, the Medical Department of the University College of Sheffield has received £1000 for the purpose of founding a scholarship for second-year students.

We learn from *Nature* that by the will of the Mr. W. Hiddingh, who died on December 10, 1899, the University of the Cape of Good Hope is bequeathed the sum of 5000*l.* for the foundation of a scholarship to enable young persons to pursue and complete a course of professional study, the scholarship to be tenable for four years. To the University is also bequeathed the sum of 25,000*l.* for the purpose of building a university hall and suitable university offices, and a large piece of ground for the site of the building. The South African College will receive the sum of 10,000*l.* for the erection of a students' building.

The University of Nebraska celebrated its thirty-first anniversary on February 15th, known as 'Charter Day,' by an oration by Dr. Allen R. Benton, Chancellor from 1871 to 1876, and since then of the faculty of Butler University, Irvington, Ind. After the oration, degrees were conferred upon six students who had completed the work for the degree of B.A., and upon one who had completed the work for the degree of B.Sc. The Regents, at their Charter Day meeting, discussed again the all-year-plan, *i. e.*, the plan of having four quarters of instruction, as in the University of Chicago. The subject was again referred to the Regents' Committee on Courses of Study. Dr. T. L. Bolton, of Clark University, was elected Instructor in Philosophy, to fill the place made vacant by the recent death of Dr. Leon M. Solomons. Although the chancellorship was discussed, no election was made. It is the expectation of the Regents to make an election at their April meeting. The new Experiment Station Hall was accepted from the contractors, and it will be occupied at once. A contract was let for the completion of Grant Memorial Hall, by the building of a large transept which will double the capacity of the hall. The sugar-beet industry, in Nebraska, having passed the experimental stage, the Regents ordered the discontinuance of the sugar-beet experiments on the Experiment Station.

Another bill has been introduced into the Senate, establishing a University of the United States. The bill provides that the government of the university shall be vested in a board of regents to be composed of the President of the United States, who shall be president of the board; the Chief Justice of the United States, who shall be vice-president of the board; the commissioner of education, the president of the university, the secretary of the Smithsonian Institution, the president of the National Academy of Sciences, the president of the American Association for the Advancement of Science, the president of the National Educational Association, the president of the American Association of Agricultural Colleges and Experimental Stations, the president of the American Historical Society, the president of the Washington Academy of Sciences, the presidents of the ten institutions of learning exclusive of State universities having the largest number of graduate students doing systematic original work; the presidents of the ten State universities having the largest number of graduate students engaged in like manner; the presidents of the ten other institutions, in as many States, not otherwise represented, having the largest number of students in the senior class of the academic departments, and six other citizens who, with their successors, shall be appointed by the President of the United States, by and with the advice and consent of the Senate. It is provided that 'University Square,' recently occupied by the old naval observatory, in this city, be the site for the national university.

MEDAL IN HONOR OF DANIEL GARRISON BRINTON.

Struck by the Numismatic and Antiquarian Society of Pennsylvania.